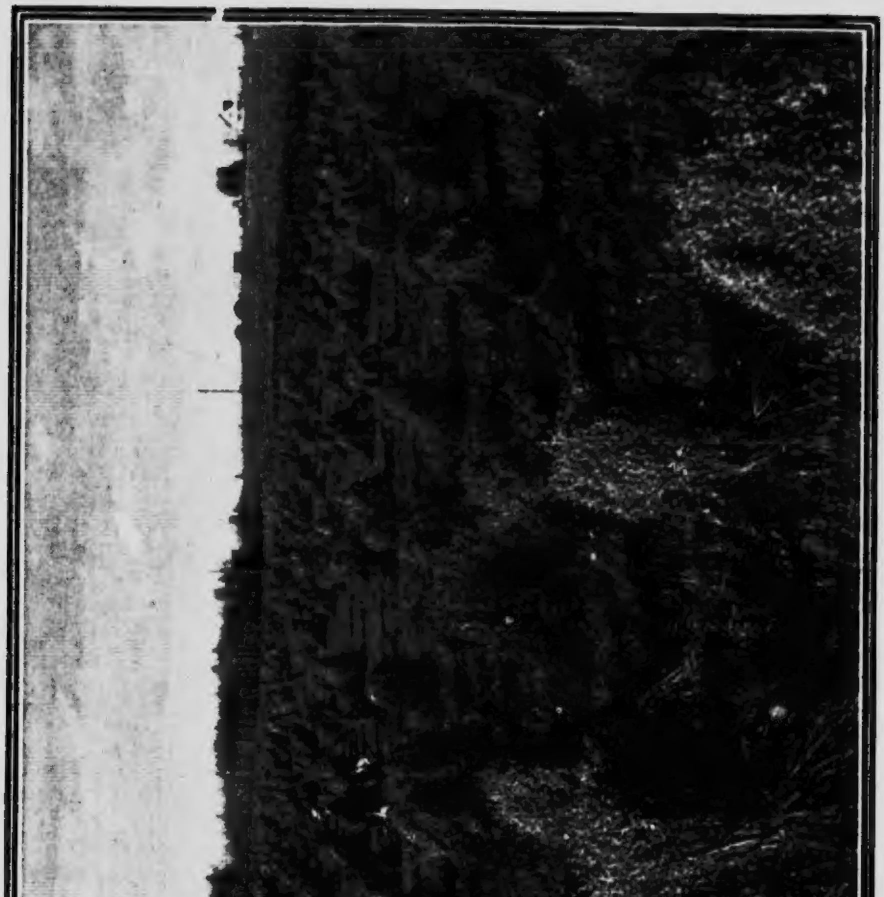
ELEMENTARY AGRICULTURE for SCHOOLS



ELEMENTARY AGRICULTURE

FOR

ALBERTA SCHOOLS

BY

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Authorized by the Minister of Education

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PREFACE

There are two outstanding reasons why Agriculture should be regularly included in the programme of studies for public schools. One of these is, that in a country that is dominantly agricultural, it enables the child to pass easily into the characteristic life of the community. The other is, that under proper organization of its materials, it embodies more completely than any other subject of the public school the interesting beginnings of practically . the natural sciences. It is thus the complement to subjects that are more or less scholastic. As an applied science it is dynamic in aspect, and under proper treatment meets the demands for the concrete in elementary teaching. The science of agriculture in its higher aspects has now progressed to a stage at which the diverse materials of the simple sciences, such as geology, physics, chemistry, botany, bacteriology, entomology, etc., on which it is based, have been harmonized into a body of knowledge worthy of being itself called a science. From this it is possible to set out in like relation its elementary principles and facts to the broadening of the experience of public school pupils. To this broadening of experience the pupils of the elementary schools are entitled.

The last two years of the public schools are the meeting ground between the science and art of the high, technical, and vocational schools on the one hand, and the nature studies, geography, and practical school arts of the elementary grades of the public school on the other. The subject should display some organization, but the methods of the elementary grades should persist. There is no opposition between the

practical and pedagogical demands of agriculture teaching with respect to either method or matter except such as results from the limitations of the public school. Logical arrangement of matter and proper methods of teaching are of equal importance in the securing of interest and understanding.

The book has in view the limitations of the public school with respect to the teaching of a subject that is an art as well as a science. The public school is not a trade school. The teaching of agriculture in the public school is education through agriculture rather than agricultural education. At the same time, agriculture is an applied science, and the parts of it that can be properly taught are the parts that should be included in the public school programme of studies. Practically the whole of the book is taken up with materials that are at hand, as soils, plants, tillage, and crops. Part I is a series of studies concerned with finding out how natural forces have operated to establish a home for the plant. Part II is a study of the life cycle of the general plant. The pupils already have some acquaintance with soils and plants, but organization should go step by step with the acquisition of knowledge.

Part III, which deals with tillage, includes more matter than is commonly found in text-books on elementary agriculture. This is in harmony with the progress that has been recently made in soil physics and with the emphasis that is being placed on soil condition, rather than on soil content exclusively, as a result of this progress. It is likewise in accord more particularly with the dominant problem of prairie agriculture in meeting our not too plentiful moisture supply by careful cultivation for moisture conservation. While the emphasis to be placed on the different chapters of Part III varies in different parts of the prairie, this section is intended to furnish an important part of the material for teaching in the second year. Part IV, which deals with crops, is subject

to limitations for public school work, chiefly as to the chapters dealing with individual field crops. The aim of it is the teaching of representative crops rather than the details of management of particular crops.

The use made of the materials of the text-book should be influenced by the fact that it has to serve for both urban and rural schools, and the emphasis on different parts of the book should vary with local needs. The chapters on trees and on gardens and grounds are rather general in treatment in order to preserve the balance of the text. The materials of these chapters should be supplemented from bulletins on trees and on flower and vegetable culture and on school gardens. The book naturally falls into two sections, the first two parts being introductory soil and plant studies, while the remainder is concerned with practice or application.

The introduction and the two chapters of the supplement are necessary to the placing of the detailed studies of the book in their proper setting. The introduction sets out the uses to which soil is put and the importance of agriculture in general economy. The two chapters of the supplement, dealing with types of farm enterprise and types and breeds of farm animals, are intended to indicate the importance of the superstructure of stock-raising on crop-growing rather than to furnish a body of material for detailed study by pupils. The effect and value of these chapters relating to general economy depend almost wholly on the effort and skill of the teacher. The live stock illustrations should be used to develop a keen appreciation of good animals and of characteristic types. A number of the more general farm and live stock illustrations have been interspersed with the reading matter throughout the book to develop interest from frequent incidental inspection.

Following each chapter of the book are exercises based on the matter of the chapters. These contain the laboratory

work of the subject, review questions, and also deductions on the matter of the chapters. The experiments may be performed either before or after the matter of the chapter is dealt with. They do not require elaborate equipment and make only a modest demand on the resources of the teacher. The laboratory work in the school, in the home and school garden, and in the field, is essential. The possibilities of the subject for laboratory treatment should constitute its chief attraction.

The author has pleasure in thanking those whose names appear as contributors in the list of illustrations as well as those who have given helpful criticism and information during the preparation of the manuscript and whose names are given below: J. A. Fife, B.A., Inspector of Schools, Edmonton; J. Bracken, B.S.A., Professor of Agronomy, University of Saskatchewan, Saskatoon; W. H. Fairfield, M.Sc., Superintendent of Experimental Farm, Lethbridge; W. G. Carpenter, B.A., Superintendent of Schools, Edmonton; G. H. Hutton, B.S.A., Superintendent of Experimental Farm, Lacombe; H. A. Craig, B.S.A., Deputy-Minister of Agriculture, Edmonton; W. J. Black, B.S.A., Principal of Manitoba Agricultural College, Winnipeg; E. A. Howes, B.S.A., Dean of the Faculty of Agriculture, University of Alberta, Edmonton; W. C. McKillican, B.S.A., Superintendent of Experimental Farm, Brandon; S. G. Carlyle, B.S.A., Superintendent of Demonstration Farms, Edmonton; J. R. Tuck, M.A., Normal School, Camrose; M. H. Long, B.A., High School, Edmonton. The drawings were executed by W. Thompson of Edmonton.

J. McCaig.

Edmonton, January 1st, 1915.

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CHAPTER I

INTRODUCTION

The Uses of Land. Agriculture in a broad sense is the use of the soil for the production of plants and animals that are useful to man. The most common use of the word **agriculture** is that in which it stands for the production of field crops such as grains, grasses, and roots. By extension it is taken to include the breeding and care of live stock for work or for the production of meat and milk on the products of cultivation. This is called **mixed farming** or **general farming.** The special production of milk is called **dairy farming.** The grazing of stock over wide areas with a minimum of cultivation is called **ranching.** It may be concerned with horses, cattle, or sheep, and so is called horse-ranching, cattle-ranching, or sheep-ranching.

The word ranch originally had the same meaning as farm. With us it has not been commonly associated with cultivation, though where ranching has been dominant the word ranch is colloquially applied to farm enterprises. **Horticulture** is the name given to garden

or orchard cultivation. The art of growing flowers is called **floriculture.** As our timber supplies become reduced we now grow trees for their wood as well as for shelter or decoration. This is called **forestry.** According as soil is carefully and thoroughly tilled and treated for heavy production on small areas, or is only simply tilled over large areas, we have what is called **intensive** cultivation in one case and **extensive** in the other.

Agriculture a Basal Industry. Though no civilization can be considered high that has not a variety of industries and activities, it is agriculture that provides the world's food and clothing, and that makes other great activities, such as those of manufacturing, transportation, and exchange, necessary or possible.

Food and Clothing. Foods are of various kinds. The simplest of these are the roots and vegetables of the fields and gardens. Fruits are universally used as food, subject to the adaptation of countries for their culture. Cereals of all kinds are used for human food. All these foods are staple foods and are derived directly from the soil. Meats are indirect products from the soil. Our meat animals are grown on the crops of the farm and on the native grasses. Milk is also an indirect product. In the making of butter or cheese and in the curing of meat the farmer becomes a manufacturer. Clothing is made from the fleeces of sheep grown

on the farms or from the cotton grown on the plantations in other countries. Flax furnishes both textile and food products as well as oil.

Manufacturing, Transportation, and Exchange. The products of the farm are the r w materials for many factory industries. The wheat, oats, barley, flax, sugar beet, and wool of the farms support the most important milling industries of the country. The surplus fruits and vegetables of the farm and garden make work and business for the canneries. The packing houses are supplied from the live stock of the farm. The side products of the animal support such subsidiary industries to the packing houses as the making of soap, glue, and fertilizer, and the tanning of hides. Harness-making factories, boot and shoe factories, and glove factories are dependent on hides prepared in the tanneries. The heavy products of the farm, such as grain, live stock, and roots, make work for the transportation companies, and the same materials in raw or manufactured state are the chief commodities of commerce. It is thus seen what a large part the products of agriculture play in the economy of the country. They are the chief source of national industry and of national wealth.

Agriculture is Complex. The use of knowledge and skill in the production of plants and animals is called the **art** of agriculture. In addition to producing crops and animals, the farmer has to

dispose of them. He also has to do a good deal of buying of foods, supplies, machinery, and stock, and generally to manage his affairs. In this aspect agriculture is a **business**. The knowledge that the farmer applies in the management of soil, the treatment of crops, and the breeding and feeding of animals, is the **science of agriculture**. It is in the science of agriculture that we are chiefly interested. A knowledge of business is gained in actual business, skill in an art is secured in practice and experience, but the elements of the science can be studied at school. This applies chiefly to soil and plants, which are about us everywhere, or which may be brought into the school. We should get the science of things from a study of the things themselves.

EXERCISES

1. What kinds of crops are grown in your neighborhood? 2. Are the crops that are grown sold or fed principally? 3. Make a list of the farm products marketed from your district. 4. Make a list of the products from the farm that are used on the farm. 5. Explain the difference between ranching and farming as to: the character of the operations, the labor employed, the area of land used and the total returns from the land. 6. Which is the most important industry in your province: agriculture, mining, or manufacturing? 7. What industries or businesses may be involved in the raising and disposition of a cow and her products? 8. Explain the difference between the art of agriculture and the science of agriculture. Are they related to each other?

CHAPTER II

SOIL AND ITS ORIGIN

Soil. The word soil is used in a variety of ways. The outer part of the globe, so far as we can judge, consists of a rock crust covered with rock waste, such as clay, sand, and gravel. In some places the waste material fails to cover the rock; in other places it is several hundred feet deep. The whole of this waste material is commonly called earth, but is sometimes also called soil to distinguish it from rock.

In most places where the rock is covered with earth, the earth is covered with vegetation. It may be trees, shrubs, grains, grasses, or flowers, and these may be cultivated or wild. In other places there is no vegetation. We recognize that earth is necessary for vegetation and that all kinds of earth are not equally suitable. If we examine the earth in which plants grow we find that at the surface it consists of a dark layer which appears to be decayed vegetable matter itself mixed with clay or sand. We shall find out later that this is a result as well as a condition of vegetation, but for the present we shall content ourselves with observing that it is in this dark earth that our plants

grow or grow best. The layer of dark earth may be only a few inches in depth or it may be several feet, and it may be darker in some localities than it is in others. Usually there are only a few inches of dark earth at the surface, while the earth below is colored for a little distance down by the vegetable material at the surface. The roots of plants are seen to penetrate often to a depth of two or three feet, the depth depending upon the character of the earth and also on the habit of the plant. In any case there is a portion of the earthy material at the surface in which the plant lives or which is suited to the support of plant life. This is true soil. The term soil in its right sense stands for the whole surface layer of earthy material that is concerned with the support of plant life. This is a general use of the word.

The work of agriculture has been found to depend on a great many of the natural sciences, and the knowledge underlying it has been gathered into what is itself called the science of agriculture. The accurate use of terms is necessary in the sciences. The word soil is perhaps used more often than any other word in agricultural discussion, and in such discussion it has a special meaning. Tillage is the fundamental operation in agriculture and, since tillage of the farm or garden directly affects only a few inches of the surface of the earth, the word soil has been given a meaning to suit this condition.

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FIG. 2. RANGE HORSES.

Soil in an agricultural sense means the part of the earth that is cultivated for crop production.

Subsoil. While tillage directly affects only a few inches of the surface covering of the earth, the character of the part immediately below is important and comes prominently into soil studies. We make a distinction between the earth at the surface and that which is below, by calling that which is below subsoil. As we limit the word soil to the depth of surface that is tilled, so we should limit the term subsoil to the part of the under-soil that is of importance in relation to plant growth. The depth to which subsoil is important is the depth to which water and air commonly penetrate or to which plant roots may find their way. The waste material below this is of no greater importance to plant growth than the rock which is hundreds of feet below the surface. Subsoil in an agricultural sense is the part of the under-soil which affects plant growth. We must associate both soil and subsoil with life.

The most apparent difference between soil and subsoil is that the soil is darker than the subsoil. The close resemblance between the decaying vegetable matter on the surface and the soil immediately below it shows that this difference is due to the presence of vegetable matter in the upper soil. Common observation teaches us that land that has large supplies of decayed vegetable matter on the

surface is very productive, and as this material is made at the surface, soil is always more productive than subsoil. This dark soil extends to a depth of several feet in many parts of the Prairie Provinces of Canada. Soil is usually finer in texture and less compact than subsoil. Very often the rock immediately below the subsoil appears to be undergoing changes by which it is being turned into loose material.

Origin of Soil. The soil and the subsoil are both derived originally from rock. This can be best understood by the observation of the soil-making processes going on about us, by the similarity of the underlying rock and the soil immediately above it, and by a knowledge of certain great changes that have taken place in the history of the earth. It is accepted as true that the materials composing the earth were once in a gaseous state and that as the earth became cool by the radiation of the heat the surface became rockbound. The globe also became smaller and was thrown up into wrinkles and ridges. The cooling of the vapors made the waters of the earth which ran into the valleys, and thus we had the separation of the water from the land. The exposing of the rocks led at once to what we call weathering. The result of weathering is soil made by such processes as we see going on about us every day. We may readily believe that the cooling process by which the world is thrown up into

ridges is still going on, so that we have two opposing activities, one within the earth, which makes elevations and irregularities in the surface, and the other without, which tears down these irregularities and fills the hollows.

EXERCISES

1. Examine the face of the soil in a railway cutting, road cutting, cellar excavation, creek, or river bank, and tell what color the soil near the surface is. 2. How far down does the soil of this color and of similar character extend? 3. What is the color of the under-soil? 4. Plant a dozen seeds of wheat from the same sample in two pots, one containing soil and the other subsoil. Compare the results as to (*a*) germination, (*b*) subsequent growth. 5. Do the colors in the soil and subsoil blend or are they rather distinct? 6. Is there any rock exposed, and if so at what depth? 7. Is the soil immediately above it similar to the rock in appearance? 8. Compare the top soil with the under-soil as to texture by rubbing it between the palms. 9. Which is the more easily removed, the upper part of a cellar excavation or the earth four or five feet down? 10. Is the under-soil on the bank you have examined all of one kind, or is it sand, clay, and gravel in different layers? If so, in what order do they come?

CHAPTER III

SOILS IN THE MAKING

It is important to know how soils have been made, as the processes by which they have originated are still going on and are reducing and changing our soils and moving them about, sometimes to the improvement and sometimes to the injury of the soils. The original source of soil being rock, we shall look into the work of the agents by which the part of soil derived from rock has been made, as well as into subsequent changes.

Agents Concerned in Soil-Making. The chief ways by which soils are made and changed are by **weathering** and by the work of **plants** and **animals**. In soil study, weathering stands for quite a number of activities, which include the breaking down of solid materials by force as well as decomposing them. **Frost** is an important agent in the breaking down of rock. All rocks have crevices in them. When these become filled with water and the water freezes, it expands, causing the rocks to split. Frost has the same effect on compacted soil that contains water and helps to reduce it to a finer state of division. **Changes in temperature** from season to

FIG. 3. CATTLE ON NATIVE GRASSES.

season and from day to night cause alternate expansion and contraction. This causes the rock to crumble and fall into decay. **Water** acts chemically on the minerals contained in rocks. Some of the minerals it dissolves out of the rock. In other cases it helps to form new compounds which are

FIG 4. DISRUPTIVE FORCE OF FROST IN ROCK SEAMS.

soft and are easily broken down. In both cases the rock is reduced. In passing through the air water absorbs carbonic acid gas, which increases its solvent power. The **oxygen** of the air unites with substances in the rock and causes decay. All rocks and soils contain a little iron, which when exposed to air changes to iron rust.

Plants act in different ways. Their roots often penetrate the crevices of rocks and cause the rocks to split. The surface of rocks is furrowed by the roots of plants which have grown on their surface.

Burrowing **animals** help to reduce the soil to a finer state of division and mix the under-soil with the top soil. Gophers, badgers, and ants are common examples on the prairie. In some places the work of earth-worms is important. They increase the circulation of air in the soil. They drag the upper soil into their underground passages, which leads to the improvement of the under-soil, and they move large quantities of the under-soil to the surface. Darwin was the first to point out their importance. He estimated that over ten tons per acre of the lower soil were brought to the surface annually in certain localities examined. The presence of worms and their number, however, depend upon conditions of tilth, climate, etc.

Soil-Moving. It is necessary to consider soil transportation among the soil-making processes. The character of transported soils differs so from soils that have remained where they have been made or near at hand, that soils are commonly classified on this basis into **sedentary soils** and **transported soils.** Transported soils themselves are of two kinds: **alluvial soils** and **glacier drift.**

Rivers, Snow, and Ice. The laying down of alluvial soil is the work of large drainage systems,

often including lakes as well as heavy streams. The gathering of materials is greatest on the steep inclines of large valleys. Every stream is discolored after a rain-storm or flood with clay or with lighter floating material. In steep channels heavier material, such as sand, is swept along the bottom of the river channels. Stones and pieces of rock go tumbling along and wear each other into sand or into smooth, rounded pebbles. As the stream reaches lower levels the force of the current weakens and the stones and pebbles settle in the stream. The sand still moves along the bottom under the curtain of muddy water and may be driven aside into bars which appear above the water on the quieter side of the stream when it shrinks, or the finest of it may pass out through the mouth of the river into the bed of the lake or ocean. Still lighter material, consisting of very fine clay or silt and vegetable mold, settles and forms rich deltas such as occur at the mouth of the Red and Mississippi. The greater part of the Province of Manitoba is covered with a rich alluvial deposit which once formed the bottom of an ancient lake, called Lake Agassiz.

Where the banks are low a river in high water may overflow its banks and, gradually subsiding, leave a light but rich deposit on the adjacent lands. This explains the fertility of most bottom lands. Alluvial soils are the most fertile agricultural lands

that we have, owing to the fact that they have large quantities of vegetable material and that they are well fined and mixed.

Moving of Farm Soils. The process of soil-moving just described is important, not only in a large way in making soil where there was none before, but in changing the soil about everywhere. On every farm where there are differences in elevation the rains are constantly at work moving soil from the hills to the hollows, and, as the best soil is on the surface, the hollows become enriched at the expense of the hills. This may be seen in the difference in color between the soil of steep hillsides and that of the hollows between them. On farms with sharp slopes and many natural drainage courses the loss of good soil each year is very great. As forests protect the soil of the hills on which they grow, so grass and other crops protect the hills of cultivated fields.

The snow and ice of high altitudes assist in the work of transporting soils as they furnish materials to the streams. Avalanches sweep the sides of the valleys clear of vegetation and of soil and even coarser material. Glaciers grind and pulverize the rocks of valleys in their descent and furnish soil and rock material to the streams springing from their base.

The Great Glacier. The second kind of transported soil, called drift or glacier drift, originated from a great continental glacier. At one time the

upper part of North America, as well as parts of Europe and Asia, was a great ice field. The steady accumulation of ice in northern latitudes and the thawing of the ice at the southern fringe of the ice field started the southerly movement of this mass, which ground and pulverized everything in its

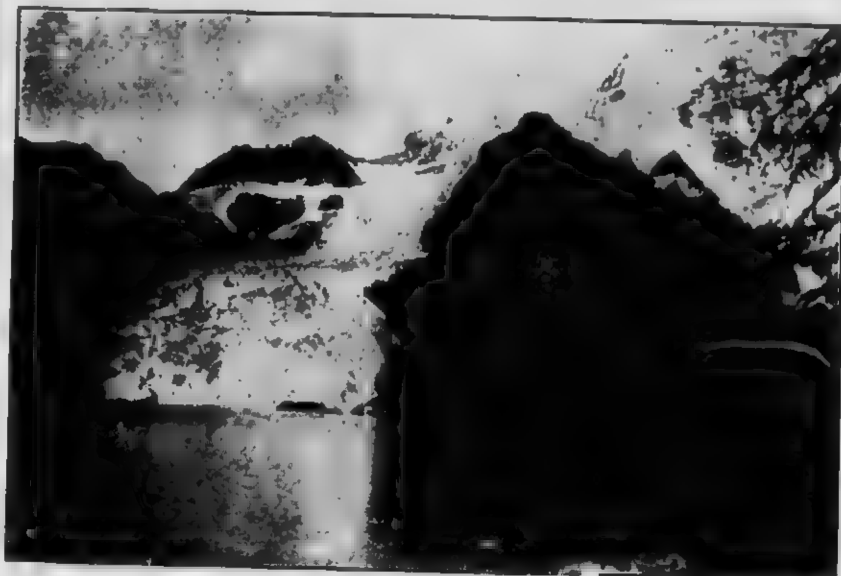

Fig 5. Soil-Making in Higher Altitudes.

way. In the path of the glacier field were left the clay and gravel, and in some cases boulders, that form the covering of much of the underlying rock of the Great Central Plain. This soil provides rich supplies of mineral food materials for plants. It is the basis of our soil over practically the whole of the Prairie Provinces.

Wind is an important agent in soil-moving. In dry countries swept by strong prevailing winds the

results are important. Immense beds of soil, called loess, have accumulated in China as the result of wind. There is a constant movement of dust to the leeward edge of the drier parts of the western interior of North America. Finely cultivated fields unprotected by crop often lose the greater part of their surface mold by blowing. Deep accumulations of sand appear on the eastern shores of lakes and sometimes cover up more productive soil.

EXERCISES

1. Give common examples of the disruptive force of frost. 2. Examine the outer and inner surfaces of a fresh chipped piece of rock and explain the difference. 3. What changes are likely to take place in heavy, clay, ploughed land over winter? 4. Contrast its appearance in the spring with its appearance in the fall. 5. What does the appearance of boulders or pebbles tell of their history? 6. Is the movement of black soil from the hills to the hollows likely to be greater in cultivated soil or in virgin soil? 7. How would you explain the occurrence of a greater depth of black soil on the hills than in the hollows where it occurs? 8. Compare a wooded slope with a bare one as to erosive action and explain. 9. Is the flooding of land by irrigation likely to be of benefit in any other way than in the furnishing of moisture?

CHAPTER IV

ORGANIC AND INORGANIC CONSTITUENTS OF SOIL

It has been shown that soil-making began as soon as the surface of the earth became solid and the water became separated from the land. The action of climate or the weather, which is just day-to-day climate, may be assumed to have been the same from the beginning as it is now. The heat and cold and water did their work of physical disintegration, and the moisture and gases their work of chemical decomposition on the rock surface of the earth. Plants likewise have been seen to act both physically and chemically; in one case cleaving the rock by the force of growth; in the other decomposing the rock by the acids secreted in plant growth.

Agricultural Soil. The work of all these agencies, important as it is in the first place, does not give us agricultural soil. We have seen that the most obvious difference between soil and subsoil is a difference in color. The surface of the earth is covered with dark material. If we dig down into the earth or if we observe the face of the soil on a cutbank or other steep exposed surface, we find that

the earth becomes of a lighter shade as we go down. It usually continues dark for some distance and then becomes grey or brown or red. The changes in color may be rather abrupt, but generally they shade into each other, the dark of the top soil penetrating into the soil below. The blending takes place in moist climates to a greater extent than in dry climates and usually to a greater extent in cultivated soil than in wild, or so-called virgin soil. In any case there is a sharp contrast in color between the top soil and the soil at any point below it which indicates a different quality and origin.

The top soil is not wholly the result of the same processes as have led to the breaking down of the parent rock, but to other processes working at the immediate surface of the earth, and of perhaps greater importance in preparing the earth for the work of cultivation and production than the original work of soil-making has been. The dark-colored soil at the surface of the earth is not wholly derived from rock but from entirely different sources.

Organic and Inorganic Substances. This double origin of the soil is usually expressed by saying that soil is made up of both organic and inorganic material. An organic substance in an ordinary sense is a substance derived from something that has had organs or parts and that has had life, such as a plant or an animal, in short, that has been organized. It may be the bones or other parts of

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FIG. 6. TWO CROPS A YEAR EVERY YEAR.

an animal or the parts of a plant, such as leaves, twigs, or roots. Anything that does not show organized structure, or of which one part is the same as another, such as minerals, metals, gases, or water, is inorganic. To make a soil we must have both organic and inorganic materials. The proportion of inorganic material is usually much greater than the proportion of organic material, but it varies in different soils. Subsoil, like soil, contains both organic and inorganic material, but the proportion of organic material in subsoil is much smaller than it is in soil. The reason for this is plain. Rock materials are the foundation of all soils and are below, while organic materials are supplied by plants and animals which live on the surface of the earth. The organic materials are likewise always lighter than the inorganic materials and so tend to remain above the inorganic materials.

Humus. The name given to the kind of soil made from the decay of organic material is humus. It is derived chiefly from plants. Leaf mold and peat are common examples of this kind of soil. The decaying material left by plants is a real addition to the soil. The plant in giving up its life to the soil, whether it be the humble lichen or great forest tree, is not merely giving back what it has already taken away from the soil, but is adding to the soil material which it has derived from the air, so that the continuous growth and decay of

Fig. 6. Two Crops a Year Every Year.

plants may result in deep accumulations of black soil or humus. The best example of the accumulation of vegetable material to great depth is seen in the deep, black soil of heavy forests. The rich soils of the Prairie Provinces have been made by the growth and decay of vegetation through ages. The appearance of soil from color alone might lead one to believe that a soil may be practically all vegetable mold for four or five feet down. This is not the case. A pure peat bed may contain up to about seventy per cent of humus. The rest is fine sand or clay. A very rich garden soil that has been steadily enriched may contain up to twenty-five per cent of humus, but ordinary agricultural soil contains from four to nine per cent, or in some cases twelve per cent of humus.

Dry Analysis of Soils. It is possible to find out what proportion of a soil is organic and what is inorganic. This is done by drying and burning. For this purpose take about a peck of garden or field soil. Turn it out on a table and work it over with the hands to reduce it and mix it at the same time. Gather it up into a round, even pile and cut into four equal-sized parts with a thin board. Throw away opposite quarters and repeat the process with the remaining quarters. Do the same thing a third time. This is called **sampling** the soil, which is getting a small quantity that fairly represents a larger quantity. Weigh out half a pound of what

is left. Let it stand in the sun for a day. This is **air-drying** it. Weigh it. Put it into a shallow pan and put it into the oven for four or five hours. This is **kiln-drying** it. Weigh it. The difference between this weight and half a pound tells what amount of moisture it contains which can be expressed as a percentage. Put the soil on a pan or shovel and set it on red hot coals. Keep it on the coals and stir it until it stops smoking. Weigh it. The final weight is the inorganic part of the soil. The difference between its final weight and the weight of the kiln-dried soil gives the quantity of organic matter in the soil. Express these weights in percentages.

EXERCISES

Vary the experiment set out in the dry analysis of soils by using one of the following types of soil: 1. A sample from the highest point of a cultivated field. 2. A sample of soil from the lowest part adjacent to the highest point. 3. The loose mulch from a woodlot or bluff after the dry leaves have been cleared off. 4. A sample of soil in the next six inches under the mulch. 5. A sample of subsoil from a depth of four or five feet.

CHAPTER V

CLASSIFICATION OF SOILS

It has been seen that the two kinds of soil constituents are inorganic materials derived from rock and organic materials derived from plants and animals, but chiefly from plants. The rock materials must be in a fine state of division to constitute soil. Gravel is not soil, though it may be found in soil, and gives it a certain character or condition. Hence we speak of gravelly soil. The common or standard ingredients of soil which have their origin in rock are sand and clay, and these two along with the humus of organic origin make up the solid ingredients of soil, or of a soil.

Sand. In order to understand the value or importance of sand as an ingredient of soil we shall use the common description of soil as the home of the plant. This means that the soil is the place where the plant lives or stays as well as the place where it takes its food. It is in housing rather than in feeding the plant that sand is important. Sand consists largely of silica, which is not a food for plants. We could produce nothing from a soil of pure sand. The value of sand in soil is that it gives to it certain qualities

FIG. 7a. WASTE IN DISPOSING OF CROP RESIDUE.

FIG. 7b. ECONOMY IN DISPOSING OF CROP RESIDUE.

that have an effect on the growth of the plant. It gives to humous soil a weight and substance that enable it to hold plants. Rich, peaty soils are sometimes artificially improved for vegetable growing by the addition of sand. The drainage qualities of humous soils are improved by the addition of sand. It also improves clay soils. A clay soil is usually compact, and does not admit air and moisture easily. Sand makes such soils more loose and open. The farmer usually refers to clay soil as **heavy soil** and to sand as **light soil,** though actually clay is not as heavy as sand. Sand is said to make clay soil lighter, which means that it is more easily worked. As sand admits air and moisture easily it helps to bring about the changes in plant food materials that make these materials available to plants. On the other hand, a soil that is very sandy allows moisture to pass through it rapidly, in which case it is said to **leach.** This means that it allows water to carry away and waste plant foods, and also that it dries too rapidly. A sandy soil with sufficient humus is a good soil in a wet season. It is loose in texture and is well suited to the production of roots and vegetables. Sandy soil is a **warm soil,** because of its small water content.

Clay in a pure state does not contain any of the essential constituents of plants though the so-called impurities of clay contain them. As an ingredient of soils it may be considered on the basis of the

same kind of properties that we have considered in sand. These are practically the opposite of those of sand. In the first place it is adhesive and compact. The particles of sand separate or fall apart easily whether wet or dry. Clay, on the other hand, if moistened sticks together, and if dried becomes very hard. If sufficient heat is applied it becomes as hard as stone. This quality explains its use for the making of brick and of different kinds of tile. While sand both receives and gives up its moisture readily, clay receives it slowly and gives it up slowly. Clay is hard or stiff in working and so is called heavy. Owing to its close texture and compactness, clay does not admit air easily or, as we said above, moisture, so that the changes in a stiff clay soil are not rapid, which means that growth is slow. In a wet, adhesive, clay soil plants may sicken and die for want of air or for want of the food that is made available by the circulation of air and by warmth. A clay soil is a **cold soil,** owing to its considerable water content.

It will be seen, that while neither sand nor clay is good of itself, either may be useful to correct faults in the condition of the other. Clay may bind up a sandy soil and help it to retain its moisture; sand may open up and warm a clay soil and so make it more easily worked, and make it more favorable to the processes of growth. Clay soils are, in a sense, more reliable than sandy ones,

as they retain moisture and also fertilizing and food materials better than sandy ones. Clay soils are suited chiefly to grass and cereal crops.

Humus. Though no single one of the three common ingredients of soil can make by itself a real agricultural soil, humus is the most important of the three. It influences the quality or condition of soils in a very important way, just as sand and clay do, and besides this, it contains carbon, oxygen, nitrogen, and hydrogen, which are among the essential elements or constituents of plants. It is derived originally from leaf mold, dead limbs and roots of trees and shrubs on wooded areas, and from the dead roots and leaves of grasses on open areas.

While humus contains a number of the essential elements of plants, these are not directly available to plants. In the decomposition of organic matter carbonic acid, ammonia, and water result, and it is these that are useful as plant foods. The supply of humus in soils is important. It is not only the most important soil ingredient from the standpoint of crop production, but it is the ingredient whose supply is under the control of the farmer. The farmer can waste, conserve, or increase the humus of the soil. When organic material is turned under it decomposes and so is in condition to be used up by the plant, hence it should be the aim of the farmer to keep up the supply of humus steadily by direct application of manure or by saving such

crop residue as stubble and straw which are frequently burned, and so are lost except for the ash or mineral constituents which they contain.

Humus is important also on account of its effect on the condition or texture of soil. It improves sandy soils not only on account of its food content but because it increases the capacity of sandy soil for retaining moisture. It will absorb and retain moisture better than either sand or clay will. It opens up clay soils and admits both heat and air to them, and so makes the conditions favorable to crop growth. It also improves the working qualities of clay soil. The color of humous soils is important also. Black colors absorb the sun's heat most quickly and radiate it most slowly. On this account the humus of soil is an aid to the decomposition processes which make plant feeding and plant growth possible.

Agricultural Soils. The three ingredients of soil have been considered separately in order to make the understanding of their properties simple. Though we may have areas of desert sand, peat bog, or clay flats, these do not concern the farmer, as they are not soils in the practical, agricultural sense. Soils are of composite or mixed character. Their classification, however, depends upon the proportion in which the common ingredients occur. They are usually classified according to the prevailing ingredients, particularly of sand and clay, which

make up the bulk of most agricultural soils, and which give to them certain physical qualities according to the proportions in which these ingredients occur. By physical qualities is meant such external or easily observed qualities as weight, porosity, adhesiveness, wetness, or dryness, and warmth.

A **sandy soil** is one containing enough sand to give it a loose, easy working quality. A **clay soil** is one that is distinctly heavy or sticky by reason of the large proportion of clay which it contains. A variety of clay soil that is common on the prairie is **gumbo**. It is very sticky when wet and very hard when dry. Soils are sometimes defined according to the percentage of sand or clay which they contain, but as soils present such a variety of combinations of sand, clay, and humus, figures are not of much use, and it is better to classify them according to their dominant quality or condition. A **peaty soil** is one consisting largely of vegetable matter. When the ingredients of a soil are fairly well balanced or mixed it is called a **loam**, which is the best kind of soil. Loams, likewise, may be either **sandy loams** or **clay loams** according to whether they tend towards light or heavy working quality. It is clear that these classes cannot be made very definite or exact. The properties of a soil are arrived at in a variety of ways: By the way it turns off the plow; by the way it

works in the fingers wet or dry; by its appearance after rain; by its position as to elevation, and by the character of the vegetation it carries. All these things should be made a matter of careful observation.

EXERCISES

1. Put an equal weight of kiln-dried sand, clay, humus, and loam separately in flower pots or in cans, in the bottoms of which holes have been made. Make the soil fine and set it rather firmly in the pots. Put a piece of blotting paper over the holes so as to prevent the escape of soil. Suspend the pots by strings or set them on strips, so as to leave them free to drip. Add water to each gradually until it runs through the pots. Weigh each pot after the water has ceased to drip. In what order do the soils rank for moisture-holding capacity? What per cent of weight of the soil itself is the water it will contain? 2. Fill one flower pot with sand, another with clay and a third with leaf mold, and scatter grass seed on the surface of each. Keep the soil moist and set the pots in a place favorable to growth. Compare the different kinds of soil as to growth and penetration of plants 3. Make a ball of wet sand and another of wet clay. Place them in the sun and compare results. 4. Put a sample of good soil in a common pickle bottle. Fill the vessel with water and shake thoroughly. Set it down promptly to settle and observe the arrangement of soil ingredients and explain it. This is called the mechanical analysis of soils by water-gravity method. 5. What different classes of soil are there in your neighborhood? Justify your classification.

CHAPTER VI

WATER AND AIR IN THE SOIL

Soil Water. In our study of soil we have found that the chief materials composing it are broken down rock and humus. We have learned also that some of the ingredients of soil, such as sand and clay, are important on account of their effect on the physical character of soil. Humus, on the other hand, while it affects the physical character of the soil, is important chiefly on account of its content. It contains food materials for plants. As plants use only soluble matter, or as we say, take food materials which they get from the soil in liquid form, water is necessary in the soil in order to have growth. Water is important not only because it is the channel by which food enters the plant, but also because it is an important constituent of the plant itself. Such crops as fresh grasses, roots, and vegetables are made up of water to the extent of from seventy-five to ninety per cent of their weight.

We usually speak of the water in the soil as soil water, owing to its intimate connection with the soil and with the activities that take place in the soil, and likewise on account of the differences between it after it is in the soil and ordinary rain

water. It should be looked upon as an actual part of agricultural soil, for no soil is of any use without it.

Three Forms of Soil Water. The source of soil moisture is rain, or rather precipitation, which includes both rain and snow. When rain falls on the

FIG. 8. LIVE STOCK FOR WORK.

land in considerable quantity it continues to settle downward into the earth by gravitation. Rain frequently falls to the extent of filling up all the open spaces in the soil. After entering the soil it runs through it to lower levels and may be carried off in drains or may reappear at lower levels as springs. Water that moves through the soil in this way by gravitation is called **free water.**

All the water that enters soil does not drain away. In settling into the earth it usually comes to a compact and almost impervious layer of earth which stops it or keeps it up. This stratum serves as a reservoir for water. It is not the immediate effect of rain that is important to crops, but the securing of a supply in the soil that is slowly used by the plant. The water that does not run through the land as free water begins a return movement towards the surface as soon as the little spaces between the soil particles are clear of free water and evaporation begins again at the surface. It forms a loose film about the soil particles and moves on from one to another by a kind of tension or attraction. It moistens all soil but does not wholly fill the spaces and so exclude the air. It not only moves upward to restore the supply used in plant feeding and lost by evaporation, but sideways, and by this means keeps all the soil in a uniform condition as to moisture. The movement of water by which it surrounds the soil particles and reaches from one to another is called **capillary action,** and the water that moves in this way is called **capillary water.**

This is the most important thing to know in regard to soil water. It is the capillary water which conveys food materials to plants, and its supply and care are important to the farmer. This water, or most of it, passes up through the plant and passes

out through the leaf. The capillary water that does not enter the roots of plants passes out at the surface of the soil by evaporation. We are accustomed from our studies in geography to think that the changes which take place in the moisture of the air consist of its condensation and falling on the earth and evaporating back from the surface of the rivers, lakes, and seas. While this is true, it is also true that water evaporates from the soil rapidly, and still more rapidly from land where evaporation is assisted by transpiration from the leaves of a crop.

Practically all the water falling on the soil runs off the soil or through it as free water or returns to the surface by capillary action, but no soil ever becomes wholly dry. When capillary water is exhausted, growth practically ceases, but even the driest road sand or air-dry soil, which is soil from which the moisture has apparently all evaporated, contains a little moisture, and if the moisture is all driven out of soil by thorough baking it will be found later to have regained a little moisture which it secures from the air. This moisture surrounds the soil particles as a very light film and adheres to it in a close and intimate way. It makes up only two or three per cent of the weight of soil, and it can be driven off only by heat sufficient to make water boil. These final traces of moisture in soil are called **hygroscopic water.** This residue of moisture

is ineffective so far as its relation to crop production is concerned.

Air in the Soil. It is by means of capillary water, or that which moves freely among the particles of soil, that plants are fed. Capillary water does not entirely fill the pore spaces in the soil. Soil in proper condition to permit of growth is made up of the soil itself, the envelope or film of moisture about each particle, and also of open spaces between these into which air penetrates freely. Plants require air about their growing parts below as well as above ground. Seed that is sown in ground that is completely filled with water, or that has become thoroughly compacted by having been water-soaked, will not germinate for want of air. If the land becomes water-soaked and remains in this condition after the plants have started they will stop growing, weaken, and finally die. Air is necessary for the root activities by which plants obtain food as well as for the life of bacteria in the soil which work to the advantage of the plant.

The Control of Soil Moisture. The source of water being precipitation, the supply is not within the control of the farmer. The amount of precipitation and the condition of the soil as to moisture give rise to important problems of soil management. While the farmer cannot stop the rain or bring it, he can suit his methods to conditions of oversupply or under-supply of moisture in the soil.

Where there is no natural slope to the land and the under-soil is dense, hard clay, the land becomes water-soaked in areas with heavy rainfalls or in other places during wet seasons. The land is cold and air cannot penetrate. When such land dries it bakes and cracks and is generally unsatisfactory for crop production. Such conditions are corrected by **drainage**, which opens the soil to air, warms it, and increases the depth of the feeding ground for plants.

Where the supply of moisture is scant or insufficient, steps have to be taken to make the best use of the moisture that falls. The system of soil management followed under such conditions is called **dry-farming**, the outstanding features of which are: deep cultivation, to allow the rain to settle into the soil instead of running off the surface; and shallow surface cultivation, to break the capillary movement of water led to the surface by evaporation.

Where the supply of lake or river water is sufficient and the surface character of the country is favorable, water is sometimes led from streams or lakes and run over the land to supplement light natural precipitation. This is called **irrigation**, which is a system in which the supply of moisture is under the control of the farmer. The management of soil to secure right conditions as to moisture is just as important as keeping up the supply of humus. Plant food is not available to crops unless the conditions as to moisture are right.

Soil in Dry and Humid Areas. Under conditions of heavy rainfall much valuable surface soil is carried away and deposited in the bottoms of lakes and seas or is piled up in limited areas of alluvial land. Water running through the land likewise dissolves and carries away plant food. In drier areas where excessive flooding and washing do not take place, there is little waste of surface soil or of plant food materials, so that, while the soil of dry areas has little humus on account of its scant vegetation, both the soil and subsoil are rich in plant foods. In areas of heavy rainfall the difference between soil and subsoil is greater than in dry or semi-dry areas. In moist climates there is considerable humus at the surface and much clay in the subsoil; in dry areas, while there is less humus, the soil is richer in nitrogen and the land generally is sandier and is capable of deeper working.

FIG. 9. TRANSPIRATION.

EXERCISES

1. To show that water from the soil passes up through the plant, cover a pot of moist soil containing a growing plant with oiled cloth or rubber to exclude moisture from the air, and invert a glass jar over the plant. Observe the interior of the jar. 2. Hold a piece of cube sugar to the surface of a cup of coffee and explain what happens. 3. Dip a marble in water and observe whether or not the water adheres to it. 4. Place a wick over night with an end in each of two glasses standing side by side, one filled with water and the other dry. Explain. 5. Account for the shape of a drop of water. 6. Compare the vegetation and the texture of the soil on two places, one of which drains properly and the other of which is covered with water after a rain. Classify the soils.

PART II—PLANTS

CHAPTER VII

GERMINATION

Examination of Seeds. Though the seeds of most field and garden plants are not very large, some of them are large enough for easy examination, and the seeds themselves can teach us a good deal about plants. Beans are easily examined on account of their size. As all seeds dry out when they ripen and are kept dry while stored, they become rather hard. To make examination easier it is better to soak the seeds in water. Take half a dozen each of scarlet runners or other large beans and of field peas and put them in a shallow dish on a piece of wet flannel and cover them with another piece. After they have been wet for ten or twelve hours the skin will begin to enlarge and wrinkle, because it gets soaked before the inside of the seed does. The wrinkling begins on the side of the seed where it has been attached to the pod. Gradually the whole seed swells and the skin becomes smooth again.

It is now in condition for examination. Split the seed with a thin knife, beginning at the convex

side, which is the side opposite the one which attaches to the pod. The skin will peel off readily. It will be found to be double, the outer skin being thick and tough and the inner one thin and transparent. If we examine the flat interior of the halves into which the seed divides, we shall find at the inner edge and towards one end, and partly between the halves, a small but well-defined structure which is attached to both sides, but breaks off from one of them when the seed is split. It is pointed at one end and resembles a pair of small feathery leaves at the other end. The two parts are held together by a kind of knot or joint. This structure is a plant. It is common to call the seed an embryo plant or to say that it contains an embryo plant. The pointed part is the **stem** of the plant. The root develops from it. The opposite end is the **bud** of the plant and the middle part is the first joint. Besides these parts we have the large halves of the seed, called **seed-leaves,** which are attached to each side of the stem so as to be a part of it. Examine the inside of the pea in the same way.

FIG. 10. EMBRYO OF THE BEAN PLANT.

FIG. 11. APPLE TREES SHELTERED BY COTTONWOOD HEDGE.

After the same method put some seeds of corn and wheat to soak. It will be found that the seeds of the corn and wheat do not divide into two parts like the grains of the bean and pea. It is possible with the point of a knife to separate a part of the seed, which can be recognized as the plantlet or **embryo,** from the bulky part of the seed. The remaining part is the flour or starch of the grain. The double leaves that appear on the stem of the bean cannot be found, but an enlargement on the under part of the stem takes its place. Besides this the seed has starch in which the embryo is bedded. Other plants having double seed-leaves, like the bean and pea, are the plants of such crops as the clovers and vetches, and of the same nature as corn and wheat, the cereals and grasses.

Steps in Germination. If seeds of the kinds we have been examining are kept between the folds of a damp cloth for a few days they will send out sprouts. The point of the stem comes out at one end of the scar on the concave edge of the bean, where the skin appears to be thin, at a corresponding point on the pea, and at the end of the corn or wheat, but in all cases on the side or end of the seed which has been in contact with the parent plant. The steps that have been so far observed in germination are the swelling of the whole seed and the appearance of the sprout. The enlargement of the seed from the absorption of water is a purely

physical change, such as occurs in the wetting of wood or any other porous material. The growth of the sprout is the beginning of the life of the plant, and this change is consequently called a **biological change.**

Moisture, Heat, and Air. The usual way to make seeds germinate is to put them in moist earth at the proper season. We have been able, however, to make the plant begin its life without the aid of soil. A dry seed, though it has vitality, is a dormant seed, but with the aid of moisture we have been able to stir it into life. We are justified in concluding that **moisture** is necessary to germination. This is the most obvious cause of germination, but it is not the only condition. In order to bring about germination we have been careful to keep our seeds in a warm place.

The need of **heat** may be seen in various ways. Water or snow may moisten the top of a bin of wheat, but the grain does not sprout until the warm weather comes. Growth ceases entirely during the winter season. Different seeds germinate at different degrees of heat. Wheat and barley will germinate at a lower temperature than corn and pumpkin seeds will. The need of considerable warmth for germination teaches us that it is not wise to sow or plant seed while the ground is cold. It not only fails to germinate readily, but it may be spoiled.

Another condition to germination is **air**. Seeds will swell if wholly covered with water, but they will not generally germinate. If seeds are buried deeply in the ground they will not germinate. If grain is sown in water-soaked ground it will not germinate at all, or will germinate slowly and the plants will be weak. If seeds are put in a sealed bottle with enough water to moisten them they will begin to germinate, but will not fully germinate. They have exhausted the oxygen of the limited supply of air in the bottle. In all these cases it is the absence or scarcity of air, or as we commonly say, of ventilation, that chokes plant activity. The three conditions of moisture, heat and air make germination possible.

EXERCISES

Observe and record results from the following experiments: 1. The planting of field seeds in two pots or boxes, one filled with moist soil and the other with dry soil. 2. The planting

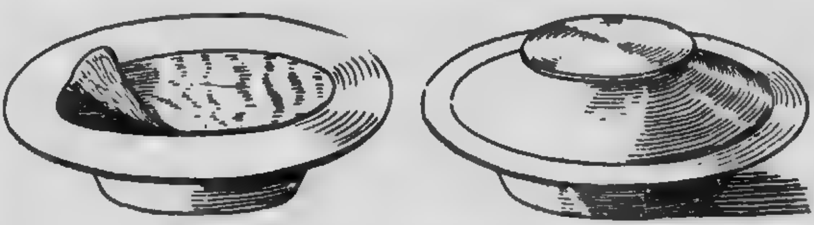


FIG 12. SEED TESTING PLATES.

of field seeds in two pots or boxes of moist soil, one of which is kept in the sunny window of a warm room, and the other in a cool cellar. 3. The placing of field seeds on moist blotting paper packed to the depth of an inch in two jars, one of which is sealed and the other loosely covered.

Make a germination test of one hundred seeds of three different samples of wheat, oats, or barley, of varying plumpness and quality, by the following method: Fill soup plates nearly level full of sand, cover the sand with a circular piece of blotting paper, place the seeds evenly over the paper, cover them with a second piece of blotting paper, saturate the sand and paper and place another plate upside down over them. Keep in a warm place. Remove the seeds that have germinated in four, eight, and twelve days. Record the number and also the number that fail to sprout. From the results of your tests estimate the number of pounds per acre a farmer would have to add to one and one-half bushels per acre allowance of seed in order to secure the stand intended if he used seed from the samples tested.

CHAPTER VIII

THE YOUNG PLANT

Plant Food in the Seed. The study of germination has shown us the nature of seed, the changes which seed undergoes in germination, and the conditions under which germination takes place. The seed holds an embryo plant which in germination bursts its way through the seed covering under the influence of moisture, heat and the oxygen of the air. Seeds ordinarily germinate in the ground, but it is not as easy to observe the process in the ground as it is in damp flannel. How is it that we can start the plant activities in this way? We must have always known, if we have thought of it at all, that the plant secures material for its growth from the soil, which is its natural home, though, as we shall see later, it does not secure all of its food here.

The reason we have not had to draw upon the resources of the soil is that the seed has within itself the supply of food that makes the changes that take place in germination possible. We have seen that in the case of the bean there is a large bulk of material in the seed-leaves that is neither stem nor bud. As soon as the bean plant gets established in the soil the seed leaves actually shrink

away. If we examine the corn kernels when the plant has become established in the soil we find that the starch that surrounded the embryo has all been eaten out and we can only conclude that it has been used in helping the plant to begin its life. The bulky part of the bean seed has been made use of in the same way, and it is true of seeds generally, that they contain within themselves the food necessary to enable them to begin to grow. Examine the seeds of flax and buckwheat for plant food.

Direction of Growth of Root and Stem. The examination of the seeds which have been started in damp flannel teaches us something besides the properties and possibilities of the seeds. As soon as the root develops it takes a direction directly downward. The single root of the bean or pea, even after it grows an inch or more in length, will form a crook to enable the extremity of the root to keep pointed towards the earth. At the same time the root will show the beginning of root hairs that spread from the main root as it increases in length. The roots of the wheat and barley appear as fibres, being three in number in the first place, and they also work downward and cling to the flannel at their tips. The downward direction of the roots is due partly to gravity, to which the tip of the root seems to be sensitive, but the bending takes place in the growing part back of the tip. The stem on the other hand goes upward. The position of the

seed at planting does not change the direction of the root or stem. If a corn seed is planted with the small end upward, the root and stem will both turn and pass each other, the root going downward seeking for moisture and the stem upward for light.

The Plant and Light. For the germination of seeds three conditions, moisture, warmth, and air, are necessary. For natural and continuous plant growth another condition is necessary. This is **light.** This along with air is just as necessary to the part of the plant above the ground as moisture and warmth are to the part below the surface of the ground. As we shall see later, the building up of plants is the result of work done both above and below the surface of the ground. The root and leaf processes are complementary.

The need of light for the growth of the plant is shown in two ways. One of these is the tendency of the plant to seek the light; the other is the effect of the absence of light in preventing normal plant growth. We have already seen that the stem of the plant immediately turns upward towards the light. If we examine the seeds we have germinated in the damp flannel, we shall see that in continuing their growth, they grow towards the outer edges of the flannel and make rapid growth when they reach the outside. This is noticeable in the case of the grains, such as barley, oats, or peas, which can be kept growing in this way until they are several

inches in length. If the stems of beans, peas, or other kinds of seeds are examined, it will be seen that at such time as they reach the light they immediately change from white to the constant color of normal plants, and they take on the sturdy quality of stem that belongs to plants that are growing in the usual conditions of light and air. If seeds are planted in a pot and set in a sunny window the plants will grow and bend towards the sunlight so as to expose a suitable amount of leaf surface to the sun. If the position is changed the direction or position of the parts of the plant changes also.

If plants are grown in poor light or away from the light they do not grow into normal plants. This is shown by a want of proportion in the plant, a want of strength, and in the absence of normal color. Stem growth is often very rapid, but the stem is weak. Leaf growth is small and the color of both stem and leaves is pale. Compare potatoes sprouted in a warm, dark cellar with potato plants in the garden as to length of stem, stoutness of stem, leaf growth, and color. Plant some barley, wheat, and radish seeds not too deep in moist soil and cover them with a board. Examine them a couple of times a week and compare them with plants grown in the open. Apply pressure to the stem with the thumb and finger to test its strength. While growth is possible without light for a time, it is not possible to produce healthy, natural plants

Fig. 13. The Farm Steading.

without it. Subsequent to the stage of germination it may be considered as one of the necessary conditions to plant growth. For continuous growth we may add light to the three conditions which we found necessary to bring about germination.

EXERCISES

For the observation of young plants, four kinds of methods or conditions may be made use of: Two folds of damp flannel in a plate; a straight lamp chimney lined with manilla paper and filled with wet sawdust or mold, the chimney being set in a pot of soil; a chalk box with a glass lid and with the end knocked out, with manilla paper next the glass and filled with wet sawdust or mold, the box being set on end; the school or home garden. In the case of the observation box and chimney, place the seeds between the paper and the glass in various positions, some with the scar end or side upwards and some with it downwards. Use beans, corn, peas, pumpkins, radish, and the grains. Make the following observations: the order of appearance of root and stem; direction of root and stem; kind of roots that develop from different seeds; method of coming out of the seed and appearing above the ground in the case of such seeds as the bean, pea, pumpkin, and wheat; the appearance of root hairs; the development of color in stems.

Make observations on the following also: Lay a pot containing a plant on its side and leave it in this position for a week. Cover one of two plants in pots with a box so as to shut out the light but admitting air at the bottom. Keep both plants in the same conditions otherwise. Plant half a dozen grains of good wheat and half a dozen of shrunken wheat in different halves of the same pot. What is the appearance of the plants at the end of twelve days? Explain. Remove the seed-leaves from sprouted beans in one or more cases and leave them on in others.

CHAPTER IX

STRUCTURE AND FUNCTION OF PARTS OF THE PLANT

The Root. A plant has two principal parts: the root and the shoot. Associated with this special organization of parts there are special duties which each part has to perform. The root has two important functions. One of these is the holding of the plant in position in the soil; the other is the gathering of food and moisture from the soil. The plant cannot take food materials through the roots except in solution, and it requires moisture also in its own composition.

The root equipment of a plant is called a **root system**. There are two main kinds of these. In one there is a central main root called a **tap-root**. Besides this it has a number of smaller side or **lateral roots**. Plants with this kind of root system are called tap-rooted plants. Examples of this kind of root equipment are the turnip, parsnip, lettuce, alfalfa, dandelion, and burdock. The other system consists of a group or bunch of similar threads called **fibrous roots**. The grasses and grains have fibrous roots, and are called fibrous-rooted plants. The greater number of plants are fibrous-

rooted. The tap-root holds the stem of the plant in an upright position, but the close contact of the smaller roots with the soil is what makes the tap-rooted plant difficult to pull up. Tap-roots usually extend to a considerable depth downward, though

FIG. 14. TYPES OF ROOTS. TAP-ROOT, FLESHY TAP-ROOT AND FIBROUS ROOTS.

much of the food and moisture of the plant is necessarily gathered near the surface. It is at the surface of the soil that rainfall is received, and the moisture that settles into the soil comes back to the surface by capillary action, carrying with it in solution plant food materials from below, so that it is at or near the surface where the chief food

supply is available. Alfalfa roots, however, have been found at a depth of forty feet, and the roots of large trees grow to great depths also in search of moisture. Fibrous roots are apt to spread laterally rather than go to great depths directly downward.

FIG. 15. ROOT-HAIRS ON THE RADISH.

The root of tap-rooted plants is in many cases the part that is of value for food. This is the case with those that are fleshy. Examples are the beet, carrot, parsnip, radish, turnip, and mangel. It takes two years for these plants to produce seed. In the first year they store up in the root food which is used in the growing of the seed in the second year. It is this stored material that constitutes the flesh of the useful garden and field roots.

Rootlets and Root-hairs. In any system of roots there are distinguishable three grades of root structures which may be called roots, rootlets, and root-hairs. The main roots as well as the smaller roots tend to become merely canals for the carrying of soil water. The work of absorbing moisture is done almost wholly by the root-hairs. The root-hairs find their way among the smallest particles of soil so as to really become a part of the soil.

They become covered with the film moisture, just as the particles of soil do, so that the roots and soil together are in intimate communication and connection through the capillary action of the soil water. If a plant like a radish seedling is taken from the ground carefully the fine earth and root-hairs will be found so closely attached to each other that they can scarcely be separated. Root-hairs may be seen on the young roots of germinating seeds, and resemble a down or pile made up of minute hairs standing out at right angles to the root. If examined under the microscope they look like simple tubes, but they absorb not only at their tips but along their walls. The root-hairs do not appear on the root immediately at the point where it leaves the stem; neither do they appear near the tip. The lengthening of the root by growth takes place just near the end, or as we say, back of the root-cap, which is a special structure fitted to work its way forward and to meet waste or wearing by rapid repair.

It is important to know the use and value of the root-hairs. If evergreen or other trees are torn from the ground with only their big roots and transplanted they will invariably die. The whole cell system of the tree becomes dry and dead before the roots can develop root-hairs to feed it. If on the other hand trees are lifted and sacked with all the root earth around them and with the minute

root system undisturbed, they will invariably live. Too deep cultivation about trees, shrubs, vegetables, and flowers often does harm. It destroys part of the minute root system which tends to spread along not far from the surface where air and moisture easily penetrate.

FIG. 16. THE BEST WAY TO TRANSPLANT YOUNG TREES.

Osmosis. The absorption of soil water is the most important function of the root system. The name of the activity by which this absorption takes place is **osmosis.** If two fluids, one of which is strong, such as salty water, and the other is weak or clear, such as clear, spring water, are separated by a membraneous wall, such as parchment or a piece of bladder, the weaker one will tend to pass into the chamber of the stronger one. The root of

the plant is made up of little cells with membraneous walls. Inside of the cells are protoplasm and cell-sap which are stronger than the soil water outside is. The soil water passes into the root and also from cell to cell up through the plant, and escapes from the plant by the pores on the under side of the leaf, leaving its food materials in the leaf.

A little of the sap of the plant also passes out into the soil. Its effect is important, as it has acids in solution that help to dissolve plant food materials in the soil. Its work may be seen in the decomposing of rock surfaces over which the roots of certain plants spread and grow. The rock surfaces show little furrows under the roots.

EXERCISES

1. Cut the stem of a sunflower, bean, or other fast-growing plant across with a sharp knife. What conclusion do you come to from the appearance of the end of the stem shortly after it has been cut? 2. What is the appearance of plants when the soil water is abundant, for example, after a rain? 3. Can you explain why a thistle or other plant dies if salt is spread about its roots? 4. Why is it advisable to prune the tops of trees that are being transplanted? 5. Cut two slices two and a half inches long, an inch wide and a quarter of an inch thick, from a fresh beet. Test them for rigidity by trying to bend them. Place one in a strong salt solution and the other in fresh water and test again. Explain.

CHAPTER X

STRUCTURE AND FUNCTION OF PARTS OF THE PLANT *(continued)*

The Stem System. The part of the plant above the ground is made up of different organs with different duties to perform, just as the part below the ground is. The name **stem** is given to the axis or central part of the upper section of the plant, and the stem, together with all the parts attached to it, is called the **stem system.** It is much more complex than the root system as to both form and work. Stems, like roots, serve as canals for carrying sap, and the leaves serve in the work of nutrition, just as the rootlets and root-hairs do, but they do their work in the air, while the roots work in the soil water. In addition to leaves, the stem bears flowers, and finally fruit, by which the life of the plant is carried over from year to year. We have, likewise, a great variety of stems, a great variety of leaves as to both form and arrangement, and a great variety in the forms of flowers and fruit. The study of these things in detail is the work of the botanist. The student of agriculture is concerned with the structure of plants so far as it helps him to understand the processes of growth.

FIG. 17. LIVE STOCK FOR MEAT AND MILK.

The Stem. The stem serves as a support for leaves, flowers, and fruit, and as a canal for the carrying of food materials between the roots and the leaves, which are the working centres of the plant. There are certain ducts in the wood by which the root sap passes to the leaves, and there are chains of cells also in the bark, through which the food that is prepared in the leaves is carried back from the leaves to build up the whole structure of the plant, consisting of the leaves themselves, the stem, bark, flowers, fruit, and root. The leaf is a centre of greater activity in plant nutrition than the root is, for it is in the leaf that the food is finally elaborated or prepared for the upbuilding of the plant.

Carbon from the Air. The absorption of water by the roots of plants can be satisfactorily shown. It is not so easy to see the leaves at their work of building up the plant from foods obtained from the air, but by unbuilding the plant we can learn that plant elements come from both the soil and the air, or, at least, that the elements contained in the plant belong properly to the soil in certain cases and to the air in others. The simplest division of plant substances is into **water** and **dry matter.** If a plant is pulled up it wilts or loses most of its water. The rest of its moisture can be driven off by drying the plant in an oven. The free water that leaves the plant by air-drying is necessary

for growth, and complete drying drives off water that is constituent water, but the really important constituents of the plant are those of the fully dried plant.

The dry matter of the plant can be further divided or reduced. If we burn a plant, most of its bulk disappears, but not all of it. We thus have **combustible** and **incombustible** parts. What is left over after burning is called the **ash** or **mineral** substance of the plant. We may conclude that this part of the plant comes to it by the soil water which is in contact with mineral matter in the soil.

The rest of the plant has disappeared as completely as the water has. We can, however, learn something of the combustible parts of the plant if we check the burning process before it is complete. If a plant or piece of wood is burned or charred in a closed vessel, that is, with the air excluded, the result will be charcoal. It is in this way that the charcoal of commerce is obtained. Charcoal is pure **carbon,** except for the ash or mineral matter which it contains. A large part of every plant is carbon. Other forms of carbon are the lead of lead pencils and the diamond crystal, which is pure carbon. It is the carbon contained in coal and wood that entitles them to be called fuel. When the plant is completely burned in the air the carbon disappears. It unites with the oxygen of the air to form **carbonic acid gas.** It is in the form

of carbonic acid gas that the plant gets back from the air the carbon, which makes up about half the weight of the dry matter of plants, and it is the special work of the leaves to secure this carbon and use it.

The Leaf. It is the work of the leaf to receive moisture coming to it by way of the stem, air by way of the pores of the leaf, and to manufacture

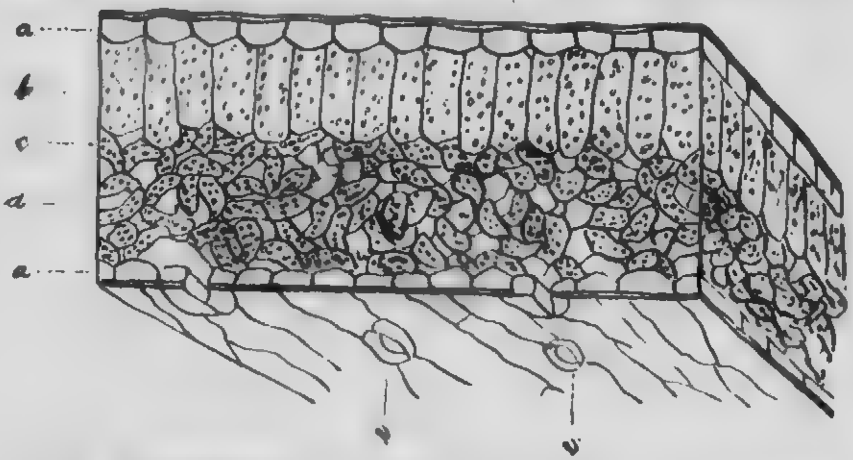


FIG. 18. LEAF STRUCTURE. *a*, EPIDERMAL CELLS; *b*, CHLOROPHYLL CELLS; *c*, TISSUE; *d*, AIR CELLS; *e*, STOMATA.

from these the food required by the plant. The leaf also permits the escape of moisture not required in the growth of the plant. The framework of the leaf may be seen by holding it up against the light of the sun. The leaf stalk divides into many branches called **veins**, and these are connected back and forth by smaller veins. It is by the veins that the soil water is led about to all parts of the leaf. The leaves are surfaces to the sun and air. The

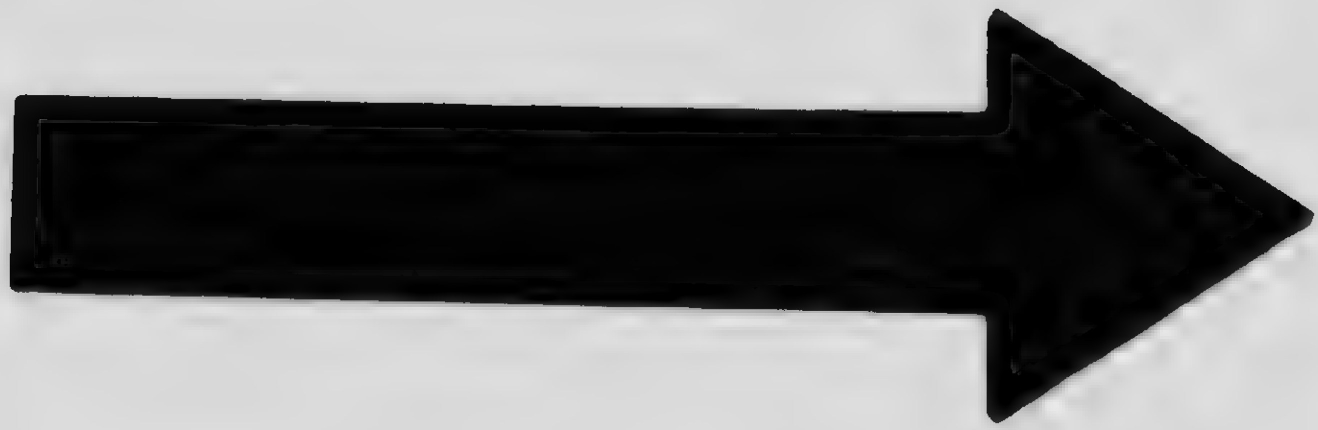
upper surface is generally smooth and bright-colored, and the under side rough and dull, but the minute structure is not apparent. The bright green of the upper surface is due to a coloring matter called **chlorophyll** in a layer of cells near the surface, and the roughness of the under surface is due to pores in the leaf, which are found chiefly on the under side, and to minute hairs which protect them. These pores are called **stomata**. It is by the pores that air enters the plant, and with it carbonic acid gas. Chlorophyll is the active agent in food preparation. It absorbs certain rays of the sun, and the energy obtained in this way breaks up the carbonic acid gas into carbon and oxygen. The oxygen is set free, but the carbon, or part of it, unites with the soil water to make sugar, and finally starch. This process goes on only during the day. By a process similar to digestion the starch, which is insoluble, is again turned into sugar, to be redissolved and carried to all parts of the plant. As the stem contains chlorophyll, the work of food preparation goes on to a slight extent in the stem as well as in the leaves.

All the starch made in the leaves of plants is not immediately used in the growth of the plants. It is stored in the stem and in other parts of the plants, and serves to promote bud growth or blossoming before general growth has started. In the case of the fleshy-rooted plants, as we have already

seen, it serves to support seed production in the second year of the life of certain plants.

Transpiration. The uses of water in relation to plant life are four. It carries food from the soil to the leaves of the plant, it carries the prepared food from the leaves to all parts of the plant, it is found in the cells of all growing plants and keeps them fresh and turgid, and it is part of the intimate constitution of plants. The process of building up a plant through the circulation of soil water is a very gradual process. It seems that only small portions of plant food materials are liberated from the soil at a time, and a great deal of water passes through the plant while it is growing. The water that is not needed to dissolve and distribute plant food, or that is not required to keep the plant fresh, passes out through the pores of the leaves. This process is called **transpiration.** It has been estimated that plants use from three to five hundred tons of water in the making of one ton of dry matter.

The movement of water within the plant is influenced by both the supply of soil moisture and the condition of the atmosphere. If there is an abundant supply of moisture about the roots of the plants, they become fresh and turgid by rapid osmosis. On the other hand, if the temperature is high, the air very dry, or th weather windy, the plants wilt by rapid transpiration. Anything that affects the rate of evaporation affects the rate of



MICROCOPY RESOLUTION TEST CHART

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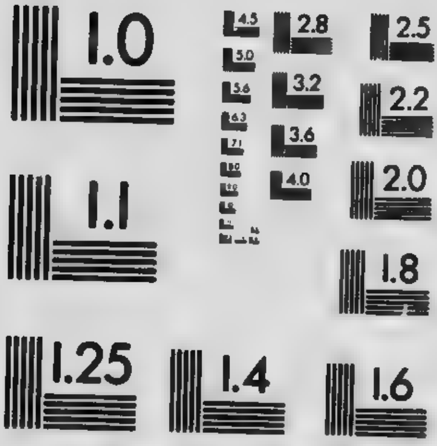

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transpiration. Plants have the capacity to limit transpiration by closing their pores when the supply of soil moisture is low, but not to the extent of preventing partial wilting in very hot, dry weather. This accounts for the rapid drying up of vegetation by hot, prairie winds.

Plants adapt their structure to suit climatic and soil conditions. The leaves of plants are usually very thin and open in structure in moist climates, but thick, fleshy, and compact where moisture is scarce. The cactus is found in dry places. It gives up its moisture so slowly that it scarcely wilts when cut and thrown out in the sun.

Importance of Leaf Growth. The root of a plant is commonly looked upon as the vital part of the plant. While a plant immediately dies when deprived of its root, it is equally clear that it cannot continue to live and grow without leaves, as it is in the leaves that food-making goes on, and from the leaves that food is distributed. The extent of the leaf system determines the extent of growth. If limbs are broken from a tree, or leaves stripped off by insects, or in any other way, the whole life of the tree is affected. If plants are grown so thickly as to shade each other, or if weeds shade the crop, the sun is shut out, and chlorophyll is not developed in the plants. Most plants that are grown in the shade of a house or fence do poorly for the same reason. Grass grows poorly under trees.

EXERCISES

1. Take a small plant with heavy leaf growth, and cut off all but a couple of inches of the root. Place it in a bottle with a little water colored with red ink. Through what parts of the root and stem does the water ascend? 2. Do the same thing with a cut stalk of celery. 3. Bind a twig tightly, in spring, with a wire, and observe the effect over a period of two or three months. At what conclusion do you arrive with respect to sap movement in the bark? 4. Explain the process of blanching celery. 5. Why are garden plants usually set out in the evening instead of in the morning or at mid-day?

CHAPTER XI

REPRODUCTION, PROPAGATION, AND IMPROVEMENT OF PLANTS

The Flower and Fruit. After a plant has about reached its natural size, or the size possible to it in the conditions under which it is growing, it sends forth flowers. Flowers are commonly beautiful and striking in appearance by reason of their form and bright coloring, as in the case of the lily or apple blossom. In other cases they are small, as in the case of the grains and grasses, or not highly colored, as in the case of corn. Their work, however, is very important. The flowers contain the parts which make the seed and so make possible the continued life of different varieties of plants. If the flower fails in its work there will be no seed and no new plants except in the cases of plants that can be started from slips or cuttings.

The parts of the flowers and the uses of these parts can be very easily studied from the [illegible] pea, though its structure is much more complex than we commonly realize if our interest has been taken up wholly with the delicate tints of the flower. Outside of the colored petals of the flower we find a little green cup for the flower. It is quite regular

Fig. 19. Seager Wheeler, of Rosthern, Sask.

Winner of World's Championship Wheat Prize at International Soil Products Exhibition, Wichita, Kansas, 1914, selecting heads in Trial Plots.

in shape and has five points. When they occur separately, each of these points is called a **sepal**; taken together they are called the **calyx**. They are not joined together in all flowers, nor is their number always five. The colored leaves of the sweet pea, called **petals**, are not all alike or regular as they

FIG. 20. PETALS AND ESSENTIAL ORGANS OF THE SWEET PEA.

are in such flowers as the lily. The pea flower has been likened to a butterfly. It is possible, however, to relate the petals to the sepals as to number, as it is with respect to the parts of the flower inside of the petals. The petals together are called the **corolla** and the calyx and corolla together are called the **floral envelopes.**

Within the floral envelopes we have the **essential organs,** called the **stamens** and **pistil.** The stamens are ten in number. They are thread-like in their

upper part, but are joined together into a thin sack at the lower end, all except one, which is free. Inside of this sack is a soft, hairy pod which contains the future seeds. The upper end of the pod consists of a tube which rises in the middle of the stamens and is called the pistil. At the upper end of the stamens are enlargements, which are really little boxes containing pollen. This pollen is liberated easily, and when the flower is opened it will be found scattered about on the petals. The end of the pistil secretes a sticky fluid to which the pollen adheres. The transfer of the pollen to the pistil is called **pollination.** It is by means of the pollen dust which grows down the tube and fuses with the contents of the pistil that the seeds are formed and matured. This process is called **fertilization.**

All flowers are not as complete as to essential organs as the flowers of the sweet pea are. Some flowers have only a pistil, while others of the same kind of plant have only stamens. This occurs in the case of the flowers of the squash on the same vine. In these cases the pollen dust has to be carried from one flower to another. This is done in some cases by the wind, corn being an example. In other cases it is done by bees and other insects that are attracted to the flowers by their bright colors and their scent or by the nectar they contain.

Propagation of Plants. The maturing of the seed makes possible the continued life of the species of

plant producing the seed. The seed is really a little plant ready to grow whenever suitable conditions are provided. Under natural conditions plants increase chiefly by seed, but not exclusively in this way. Silverweed grows stems which lean over and touch the ground where they develop roots and so begin a new plant. Blackberry bushes droop over and establish new plants in the same way. Many shrubs and trees grow suckers from

FIG. 21. REPRODUCTION BY RUNNERS.

their roots. These may be transplanted successfully. Couch grass spreads from buds on an underground stem. Nature has to provide likewise for the distribution of seeds, which is done in a variety of interesting ways, as we see in the case of the maple, dandelion, thistle, tumbleweed, and burr.

On the other hand, man plants his seeds in the places and in the order that suit him, and besides, uses a number of ways of increasing his plants that are not used by nature. All the other ways in

which plants are increased by the gardener or farmer are by a method of **division.** He increases his stock of strawberry plants in the same way as the silverweed increases, but he cultivates his plants, not only to produce fruit but to make them grow a lot of **runners.** If his soil is in good condition the runners root well. Sometimes he gets as many as ten from one plant. The strawberry grows seed, but plants from the seed do not grow true to the parent plant, as they do in the case of most of our useful garden and field plants, such as beets, carrots, turnips, and the grains and grasses. When a plant varies widely from normal type it is said to **sport.**

The most common method of division is by the use of **cuttings.** To grow currants, raspberry, or gooseberry bushes, the gardener takes slips of young wood and cuts them squarely across just below a bud, strips off a couple of buds above the cut and plants them in the fall in a bed of loose sandy soil. It takes two seasons of growth before the plants are ready to bear. Rose bushes are produced in the same way. Willows are easily grown from cuttings. They may be set in the ground where they are to be permanently, and they grow rapidly. Many kinds of flowers are grown from stem cuttings, the geranium being a common example. Others, such as the begonia, do equally well from leaf cuttings. The potato, while commonly associated with root crops, is not a root in the ordinary sense. It is

called a tuber. The potato which we use and plant is an underground stem and the eyes are buds. The potato grows seed, but, like the strawberry, it does not come true to the plant producing it, so we use cuttings from the stem. Another method of plant division is **layering.** It is commonly practised with grape-vines, but is used with many other kinds of plants, such as carnations. In layering of grape-vines it is usual to cover two buds and leave one exposed and allow the plant a season to set before severing.

All the tree fruits, such as plums, peaches, apples, pears, and cherries, are grown from **buds** and **grafts** as they do not come true from seed. The slip or part of the stem that is set is called **a scion**; the plant into which it is set is called the **stock.** The scion is set in a split in the stock. To succeed, it is necessary to have the cambium of the stock in contact with the cambium of the scion so that they may grow together. The cambium is a layer of cell tissue between the bark and the wood in which the growth of new wood takes place. The cut surfaces of both the stock and scion are covered with wax to prevent drying out. Budding, which is grafting of a single bud, is performed by inserting a bud between the wood and the bark. Plants are frequently increased by **root division.** Most shrubs can be grown in this way. A garden plant that is easily subject to root division is rhubarb, from

which as many plants may be grown as there are buds and by a rough method of division.

Plant Improvement. All of the plants we propagate and grow have wild ancestors. The most easily observed examples of tame and wild plants of the same general kind are the strawberry, raspberry, blackcap, thimbleberry, cherry, plum, and grape. We cannot find wild varieties corresponding to all the tame plants that may be cultivated in a given locality, or even country, and some of these would be difficult to recognize. The resemblance of tame and wild fruits is very plain, but the differences are also striking. The tame plants are prolific and the fruit is large and juicy. The tame fruits are a great improvement on the wild ones in their usefulness to man. The changes in these are due to **culture,** using the word culture to stand for all the means that have been employed to make the plant better.

Cultivation. In a wild state plants appear in great confusion. Trees, shrubs, flowers, and grasses are all competing for soil, moisture, sunlight, and air. When plants are grown by a farmer or gardener he excludes all other kinds of plants, both tame and wild. He loosens the soil to promote root development and to increase its moisture-holding capacity, cultivates it to kill weeds and to prevent evaporation, and sets the plants at such distance apart as will enable each to grow without

interfering with its neighbor, and he may even furnish supplies of moisture and fertilizing substances artificially. In every way he stimulates the plant to make the best possible growth. The continuation of this treatment from generation to generation produces some of the differences between wild and tame plants.

Selection. The changes produced in plants by cultivation are important, but not so important as some that are produced in other ways. The chief way in which plants may be improved by the ordinary farmer or gardener is by **selection.** While it is commonly said that plants and animals produce after their kind, it is also the case that no two plants are exactly alike. Plants have the power to differ in small or large ways from their ancestors. This is called **variation.** If plants did not have this habit it would not be possible to improve them by selection. By selection is meant the guiding of the changes in plants and animals by cutting out all those individuals that change in undesirable ways and keeping for reproduction those that display desirable changes. In a patch of thimbleberries or a field of wheat certain plants are always better than others, even under identical conditions of soil, sunlight and care. By using for reproduction only cuttings from the good thimbleberry plants and heads from the good wheat plants, our crops may be improved in both cases.

Examples of Improvement by Selection. Common examples of crops that have been improved by selection are the grains, the potato, and the sugar beet. Usually the care of the farmer in the choice of seed is limited to securing seed that is genuine, that is free from impurities, and that has vitality. By this means his crops are improved and his profits increased. A more effective method of improvement is the selection of seed in the field. The plants from even a handful of wheat may show striking variations. It is the selection of the best kernels from the best heads of the best plants that has given us some of our best varieties. Grain that is the result of this kind of selection and that is kept pure is called **pedigreed seed**. It is quite possible that in a single field of wheat we may observe plants in different instances that show such desirable qualities as liberal stooling, early ripening, resistance to frost, resistance to disease, shorter or longer straw, stiff straw, long heads, or large kernels, any of which may be made the basis of producing a new variety that would be an improvement on the general crop.

Corn has been subject to great improvement by selection in United States. It is a plant of great variability and wide adaptation. By the selection of varieties and of seed from individual plants that show early maturing qualities its use will extend in Western Canada.

FIG. 22. THE PRODUCTION OF FULLY MATURED SEED CORN IN LATITUDE 54.

The potato is an interesting example of the work of selection, in one case to conserve the purity of variety, and in the other to improve the quality and productivity. The potato is reproduced from the tuber because the seed does not come true. The improvement of the potato is commonly brought about by selecting tubers for setting from the best producing hills and by choosing the best formed potatoes.

The sugar beet has been raised in sugar content from eight to eighteen per cent by selection. The sugar beet is a biennial. It produces its seeds in the second year. The way it has been improved has been by the selection of well-formed beets in a given year and the analysis of the sugar content of a portion of each beet which can be bored out without injuring the beet for replanting. The beets of the highest sugar content are planted for the production of seed for subsequent use.

Hybridization. The kind of improvement we have been speaking of is based on the variations in plants as we find them. Specialists in plant improvement bring about variations themselves. This is done by crossing two varieties of the same species. The result of crossing two such plants is the production of a **hybrid**. We make a hybrid by taking away the pollen from a flower before it has had time to act and afterwards dusting on the stigma that remains pollen from another variety.

The hybrid shows a new combination of the qualities of the parents which distinguishes it from either of them. The work of producing new varieties that are desirable is not easy and there are hundreds of failures for one success. It requires patience or even genius. The most important improvements in plants are made by hybridization and selection rather than by selection alone, but they are difficult to establish.

EXERCISES

1. Make an examination of the flower of fireweed, morning glory, vetch, and common mustard, so as to recognize their common parts. 2. Conduct experiments at home with cuttings of house plants, bush fruits, and willows to demonstrate the method of increasing plants by division. 3. Dig up a complete potato plant carefully to find out to what part of the plant the tubers belong. Make a drawing of it. 4. Make lists of useful and ornamental plants in the house, garden and field that are grown from seed, from stem cuttings, from root cuttings and by more than one of these. 5. Examine a plant of blue grass to find out its root habit. Compare it with timothy. 6. Count the stems on a single wheat plant. Can you form an opinion as to why the number of stems varies? Examine the plants in the field for this purpose. 7. Conduct an experiment in potato growing covering two years, using large, smooth potatoes and large, irregular potatoes, six hills of each, planting not more than three sets in a hill and sets from a single potato in each hill. Devise your experiments for the second year based on selections from the results of the first year.

CHAPTER XII

PLANT FOODS

The Constituents of Plants. In the study of the structure and work of plants we have learned that plants get their foods from two sources, the soil and the air, and that they get this food by means of the activity of roots in one case, and by activities in the leaves and other parts of the stem system, in the other. In the unbuilding of the plant we first separated the water from the dry matter by heating the plant in the oven. By burning the plant in a closed vessel we got charcoal, which is made up of carbon and ash. In completely burning the plant we restored its carbon to the air and found that only the ash remained. We have thus found that the plant consists of combustible material and ash, the former of which has been driven into the air, while the latter has fallen to the ground.

While it is possible for the chemist to separate the plant into the elements composing it, about a dozen in all, just as it is with any other material substance, it is found that the plant does not use these elements separately but in compounds, except in the case of oxygen, a little of which is used by

plants in respiration, just as it is used by animals and human beings.

A compound is a substance made up of two or more elements. We have already learned that carbon enters the plant as carbonic acid gas. Water, which plays such an important part in plant growth, is made up of hydrogen and oxygen. Nitrogen, which is an important element in plants, is taken up in the form of nitrates, which are compounds of nitrogen formed in the soil. The sources of this nitrogen are small quantities of ammonia and nitric acid, which are washed out of the air by rain, and nitrogen compounds, which result from the decay of organic material in the soil. These four elements, or substances made from them, are important, as they make up about ninety-eight per cent of the green plant. They are called the organic elements because they form by far the larger part of all organic bodies. The mineral elements are just as necessary to the life of the plant as the organic elements. The necessary ones are six in number: phosphorus, potassium, calcium, magnesium, iron, and sulphur. They are available as plant food only in compounds. A plant usually contains two or three other elements not essential to its growth but found in soil solutions.

Soil Bacteria. The nitrogen found in combination with other substances in the soil is called **fixed** nitrogen. The two chief gases of the air, nitrogen

Fig. 23*a*. Alfalfa on Uninoculated Soil.

Fig. 23*b*. Alfalfa on Inoculated Soil.

and oxygen, are not chemically combined but exist independently, or rather are mixed with each other. On this account we call the nitrogen of the air **free** nitrogen as distinguished from the nitrogen of the soil. A certain class of plants can draw on the stores of nitrogen in the air. These plants belong to the family called **legumes**, and they include alfalfa, clover, vetches, peas, and beans. If the roots of a healthy alfalfa plant are examined there will be found small bunches or enlargements on them called **nodules**. They are caused by bacteria, which are themselves small plant organisms, that make a home and work in the roots of this class of plants. The bacteria themselves are wholly indistinguishable except under a very powerful microscope, as the smallest portion of soil contains countless thousands of them. By their activities the nitrogen of the air which enters the soil is changed to forms available to the plant. They cannot work in soil that is not ventilated. The legumes require a lot of nitrogen and they have thus two ways of getting it, for they also use the nitrates of the soil as other plants do.

Legumes Improve the Soil. The nitrogen contained in the roots and other parts of the legumes makes them a good kind of plant through which to add to the nitrogen content of the soil. All kinds of organic matter, such as stubble, manure, and green crops, which are turned into the soil,

restore most of what is taken out by crops, but the turning under of plants or even the roots of plants of the clover family increases the supply of nitrogen in the soil as the nitrogen or part of it has been taken from the air. This nitrogen costs the farmer nothing. Plants of the clover family more than pay their debt to the soil.

Other bacteria besides those working in the roots of the legumes are found in the soil, and aid in making plant food available. The soil now is looked upon as a live and busy workshop instead of a dead, inert mass. As the work of bacteria depends upon suitable conditions of heat, moisture, and air in the soil, their discovery has influenced our ideas of tillage.

Soil Inoculation. So important are the bacteria of the soil in both the life of the plant and the improvement of the soil that when alfalfa, for example, is being sown on land for the first time it is customary to inoculate the soil. This is done by scattering over it, to the extent of about a bushel per acre, soil taken from the land upon which alfalfa is already growing successfully, or it may be done by cultures provided by the various Departments of Agriculture. Inoculation, however, should not be expected to secure special results unless the conditions of tillage are favorable.

Uses of the Different Plant Foods. As the ten elements we have spoken of are all necessary to

plant life, one is just as important as another in one sense, for without them we can have no plant at all. On the other hand, some of them are of greater interest than others, both on account of their use as well as on account of their bulk. To the farmer the plant is just a certain weight or bulk of food, and when it is found that about ninety-eight per cent of the weight of the green plant is made up of the organic substances, the importance of these is obvious. When the compounds of which we have been speaking are taken up by the plant they are all broken up and recombined into wholly different compounds. The compounds from the soil and from the air are plant foods. New compounds made from these in the plant are animal foods, and these are valued chiefly for their organic content, and are distinguished from each other by the ways in which these contents are combined.

The important food compounds in plants are called **carbohydrates, fats,** and **protein.** Carbohydrates are compounds of carbon and the elements of water, that is, hydrogen and oxygen. They make up the starch, sugar, and cells of the plant. Starch is found in the seeds of wheat, corn, and other grain, and in the tuber of the potato. Sugar is found in the juice of root crops, such as the sugar-beet, and in the sap of such trees as the sugar-maple. Fats contain a larger proportion of

carbon than carbohydrates do. They are found in all seeds, prominently in flax, but in other grains also, and to some extent in all parts of the plant. Protein contains nitrogen and a little sulphur and phosphorus in addition to carbon, hydrogen, and oxygen. Protein is found in all parts of young plants and also in seeds. It is an important part of the seed of leguminous plants such as peas and beans. It is these various substances that give a plant its food value, as they furnish the main part of the flesh and fat of the animal as well as energy.

Mineral Substances. The uses of the mineral substances to the plant are not so well understood as the uses of the organic substances, but they seem to be useful in relation to plant activities rather than for their volume. It is known that chlorophyll cannot be formed unless iron is present. Sulphur and phosphorus are found along with protein, and are thought to be useful in its formation. Potash is thought to aid in converting starch into sugar. Lime is not an important plant food, but it helps to free other foods and improves the physical condition of the soil. Of the other elements little appears to be known.

The uses to the animal of the mineral substances in plants are important, though the bulk of these substances is small. The bones, tissues, blood, and digestive fluids all contain mineral compounds.

Foods ordinarily contain sufficient mineral matter for the health or use of animals, but we supply some mineral foods directly to animals, such as lime to hens, ashes to hogs, and salt to horses, cattle, and sheep.

Exhaustion of Plant Foods. The important thing for the farmer to know is how to get, save, and use plant foods. The carbon of the air cannot be controlled or increased, but the leaf growth can be protected and the sunlight admitted so that the work of the leaves may be allowed to go on. The water that falls as rain or snow can be conserved, as it is called, by plowing the land deep and working it fine, so as to increase its capacity to receive and retain moisture. The farmer can prevent moisture from being stolen by weeds, and can partially prevent its evaporation by cultivating the surface to break the capillary movement of water. He can drain the soil in case of over-supply of water, and so admit air and warmth and allow the bacteria to work. Nitrogen is easily exhausted. Besides what is used in the crop, a good deal is washed away, as its compounds are very soluble. Ammonia gas is highly volatile. Large quantities of it escape in the free rotting of manure. There are certain bacteria also that free it as well as those that fix it. The securing of right conditions as to moisture and the increasing of nitrogen supply are the outstanding problems of soil management.

Potash and phosphoric acid are subject to exhaustion in old soils. Potash is found in unleached wood ashes and phosphoric acid in bone, but the available supply of these is so small as to be of little practical importance. The best source of supply of these for the farmer is in the stubble of the land, in manure, and in crops of different kinds that may be plowed down for soil improvement. The other elements required by the plant are found to be practically inexhaustible in relation to crop needs.

EXERCISES

1. Explain why plants are said to purify the air? 2. How is the rigidity of green plants affected by conditions in the soil? By conditions in the air? 3. Is soil exhaustion inevitable and necessary by crop production or not? What can you learn of this matter from the vegetable mold of forests, the soil of the prairie, and generally from your knowledge of how plants feed?

FIG. 24. PIONEERS IN AGRICULTURE.

PART III—TILLAGE

CHAPTER XIII

OBJECTS OF TILLAGE

Modern Tillage. In a natural state soil is very compact, due to settling by its own weight, the action of rain, snow, and frost, and the trampling of animals. We can understand that early attempts at crop-growing were largely limited to the stirring of the soil, in order to get the seed into it, and that very simple tools were used for this purpose. In many countries the work of agriculture is still very simple. On the other hand, among nations where production and commerce are active, investigations are being steadily carried on by men of science to find out how production may be improved or increased. Much has been learned about the way plants grow, about the movement of water and the action of air in the soil, about the work of bacteria in the soil, and about the effects of tillage in relation to all these things. The result is that the management of the soil has become a very important and complex business. Tillage now includes many different operations carried on in the

preparation of the soil for crops, and also in their subsequent care and cultivation, and involves the use of a good many different kinds of implements.

Objects of Tillage. The chief objects of tillage are: (1) To break up and mellow the soil to permit the penetration of roots, and to increase the contact of the root system with the largest possible surface of soil particles. (2) To regulate the movement of moisture in the soil, and to admit air. (3) To influence the temperature of the soil for the sake of growth. (4) To turn under organic matter, such as sod, stubble, manure, green crops, or weeds, in order to bring about its decomposition, and so make food for the immediate use of plants. (5) To destroy weeds, and to prevent their growth.

Tillage and Plant Feeding. The condition of a soil, with respect to being coarse or fine, is generally called its **texture.** The finest ultimate division of soil is into **grains.** The particles of soil as we see them are not soil grains, but are accumulations of soil grains, more or less closely cemented or stuck together. These are called **granules.** We often speak of the granular condition of the soil, which means the same as texture, or its condition of division. Usually, soil that has been little tilled is coarse or open in texture. The first purpose of tillage is to bring the soil into a fine state of division. Soil in a fine state of division is in the best condition for

the support of plant life. The finer a soil is, the more open and mellow it is, for each little particle has some open space around it. The more a garden soil is hoed and raked after being dug, the easier it is to set seeds or plants in it. So it is easy for the roots of farm crops to find a home in the soil if it is fine and mellow.

This is purely a mechanical advantage. Besides this, the fine rootlets or root-hairs of the plant can come in contact with a large surface of the soil particles if the particles are small and there are many of them. The plant will grow an abundance of root-hairs to take advantage of the little channels that lead them to plant food. When a plant is lifted in very fine, rich, garden soil, the root-hairs are so numerous that they hold the soil together in a mass. It is possible, with certain kinds of soil, to have the granules too small. If the soil is too fine, it does not admit air readily, and soil water does not move about in it readily. The particles become cemented together if the soil becomes saturated. This is the case with very fine clay soil.

Tillage and Moisture. The working of the soil has a good deal to do with the movement, and even with the supply, of soil water. It cannot do much to correct an over-supply of water. This condition is corrected by drainage, which is really a way of reclaiming useless land, rather than of tilling it, though surface working may hasten the evaporation

of excess water in certain kinds of soil. This does not apply to heavy clay soil, which should not be worked when it is wet.

When the supply of moisture is scant, or is not more than sufficient, it can be made good use of by right methods of tillage. Before land is broken it is very compact, and a lot of the rain that falls is lost to the vegetation by rapid surface drainage and by evaporation. The breaking of the land allows the rain and melted snow to settle into the soil. When the surface is coarse and open, the rain runs through it, and is not held near the surface, where it is most needed. The surface exposed to the upper air is great, air enters the soil too readily, and the loss by evaporation is great. When the soil is fine, the rain soaks in readily but gradually, and forms an envelope about the soil grains. We speak of the soil holding moisture, but it is just as true to say that the moisture holds the soil, for it reaches from grain to grain, and, if the supply is right, and the condition of the soil right, the water supply system of the soil is a common system.

It can be readily seen that when this is the condition of soil and of soil moisture, the food supply of plants, which must come through the water, is at its best. This fine condition of the soil is best, not only to hold the moisture that falls, but also to lead the water from the under-soil towards the surface, where it is most needed for the roots of plants. As

all soil water climbs to the surface by capillary action, there is a possibility of losing a good deal of moisture by evaporation. Light tillage of the soil helps to prevent this by breaking the connection between the soil particles in the three or four inches at the surface and the soil below it.

Tillage and Warmth. The temperature of the soil is affected by tillage. The working of soil in the spring raises its temperature, and so hastens germination and growth. Good gardeners and good farmers pay a great deal of attention to having a good seed-bed. Making a seed-bed is preparing a few inches of the surface soil carefully, by making it fine and mellow. It absorbs heat readily from the sun, and really keeps it, for it is not readily conducted into the hard soil below. It also breaks off the rise, by capillary action, of the cold water below for a while, so that evaporation is not active, and evaporation cools the soil just as perspiration does the body. Tilling the soil in the spring is not only making a good place for the seed to get food, but a warm place to begin its life. If the ground is warm, more seeds will germinate than if the ground is cold, and if germination and growth are rapid, the plants will be strong plants. Another way in which tillage warms the soil is by covering up organic material that has been lying on the surface. When this material is turned under, it ferments or decomposes, which makes heat.

Tillage and Humus. The turning under of stubble, sod, manure, green crops, and weeds, is secured by tillage. Materials that remain dry on the surface of the soil do not become part of it, but when they are turned into the moist soil they begin to decompose. In decomposing, they form acids, called humic acids, which help to dissolve the mineral foods in the soil. Carbonic acid gas is also formed, which dissolves in the soil water, and this increases its solvent power. While humus, or organic matter, is thus used up or decreased by turning it under, it is by tillage that it is made immediately available to crops.

Tillage and Weeds. Soil is frequently tilled to destroy weeds. If land is tilled sufficiently for the good of the crop, weeds will not give any trouble, but weeds are an incident to crop-growing everywhere. Where they have not been prevented by tillage, they have to be cured by it. They are destroyed because they are greedy and thirsty intruders on the support intended for the crops. They are sometimes plowed under in fallow land. In other cases they are killed by the harrows. Much of the work of cultivated crops, such as roots, tubers, vegetables, small fruits, and even young trees, is done to destroy weeds. When weeds are being destroyed by cultivation, the work should be thorough, and should touch all of the surface soil, so as to get good general as well as special results.

Fig. 25. Jersey Heifer.

EXERCISES

1. Pulverize as finely as possible, in the hands, three small dry samples of sand, loam, and clay, to study the fineness of division into soil grains. 2. Why do we remove hard lumps of soil from about the roots of plants when we are setting them out? 3. Has the watering of plants at the time of setting them out any effect besides the furnishing of water to the roots of plants? 4. What is the effect of dipping a dry wick in oil before setting it in a lamp burner? Compare this with the effect when it is left dry. Apply the principle to surface cultivation. 5. How would you expect the general introduction of cultivation to affect the occurrence of floods in prairie areas? 6. State, giving reasons, whether it is better to break prairie sod when it is wet, or when it is dry. 7. Estimate the surface area of a cube four inches each way; of the parts of the same cube cut into two-inch blocks; into inch blocks. Does this exercise teach anything in relation to the effect of fine soil division on plant feeding?

CHAPTER XIV

IMPLEMENTS OF TILLAGE AND THEIR WORK

Plowing. There are a great many different kinds of implements used in agriculture. Of these the plow has been made to symbolize the work of agriculture. Tillage is the fundamental operation of farming, and the plow is the greatest implement of tillage. It goes deeper than any other implement and so fixes the depth of tilled soil; it may turn up additions of under-soil to the processes of weathering and of mixing with the soil already tilled; it gives a complete change of air to the under-soil; it is the implement by which humus is set in the soil for decomposition, and it does the first step in pulverizing the soil in a very thorough way.

In operation the plow is a combination of the wedge and the screw. The share cuts the earth and raises it, and also begins to lay the furrow-slice over, but this is done chiefly by the mold-board which gives the furrow-slice a half turn when it lays it flat over. The work of plowing does not consist simply of turning a mass of earth upside down or setting it in ridges to be worked down by the harrow. In the act of raising and turning the furrow-slice the plow really divides it

into a number of thin layers. This is especially true of the plows with steep mold-boards. We can understand that if a six-inch deep furrow-slice were divided into six slices, each an inch in depth, that the bending of the furrow-slice by raising it would cause the upper slice to slide over the slice immediately below it. The same thing would happen with each of the five upper slices in relation to the one below it, just as the leaves of a book pass each other if bent in a thick group between the thumb and finger. The plow really does this slicing in a rough way for itself. Each upper part of the furrow soil slides over the part below it. If the furrow-slice is thin there is not much crumbling, but if it is thick the pulverizing is better done. It is the sliding of the upper parts of a furrow over the lower parts, or the forcing of the lower parts against the upper by the pressure of the plow, that makes the draft heavy in deep plowing.

Depth to Plow. The depth of plowing depends upon a great many different conditions. If a soil is a shallow soil, as it is called, having only three or four inches of properly weathered material and humus, and lies immediately on top of clay, it would lessen the usefulness of the surface or agricultural soil to turn up large quantities of the clay. Though the increasing of the depth of tillage is to be desired, only very small quantities of under-soil should be turned up for assimilation with the top soil

at a time. Deep plowing may be an injury, but it is not likely to be so with prairie soils. Prairie soils are frequently very deep soils, and in any case the difference between the top soil and under-soil is not very great, and in prairie soils deep cultivation is generally desirable from considerations of rain saving. In spite of the under-soil being poor it is often desirable to plow deep in order to open the under-soil, which may be **hardpan**; but instead of mixing it with the upper soil it is perhaps better to use the subsoil plow to increase the depth of loose soil. The chief objection to the use of the subsoil plow is the expense of a second plowing.

The first breaking of land is often too shallow. The bottom of the furrow, which is called the **furrow-sole,** becomes hard and glazed by plow pressure, and each plowing at the same depth makes it hard to break through and establish deeper tillage. Usually fall plowing is deep and spring plowing shallow, to secure winter reduction in one case and to make a quick, warm seed-bed in the other.

The management of clay soil requires judgment. It is always hard to work. When it is wet it should not be worked at all, as its granular condition is destroyed, and it becomes a dense, compact mass. About the same thing happens when it is very dry. The granules become pulverized into the very small grains of which clay is composed, and these lie so closely that they do not readily

admit either water or air. The compacting of clay soil by a reduction of its granules to soil grains is called **puddling**.

Plows. Plows are constructed to suit the work they are required to do. There are two kinds of plows, **mold-board plows** and **disk plows.** Of these the mold-board plow is more common. There are two principal kinds of mold-board plows, called **sod or breaking plows,** and **stubble plows.** The sod plow has a long, low, gradually turned mold-board, and is used to cut a clean furrow and turn it over so as to cover what is on the surface. The other has a short, high, steep mold-board, and is used to pulverize the soil and make it mellow.

The draft of a steep mold-board plow is greater than the draft of a sod plow in the same kind of land. It is possible to use the steep mold-board plow only in easily plowed land. The long mold-board plow has to be used in new land or tough sod where we have to be content with turning the furrow over to secure the rotting of vegetable matter without doing much pulverization of the soil. The share of the breaking plow has a long, oblique edge to make the cutting of roots easier and also to make the holding of the plow easier. Soils that are naturally loose, such as sandy soils, do not need the work of the stubble plow to pulverize them, and a long mold-board plow or an intermediate kind is more suited to these soils.

The disk plow consists of a single working part which cuts the soil, lifts it, and turns it over, crumbling it pretty well in the operation. The disk plow is mounted on wheels, and it does not glaze and harden the bottom of the furrow to the point of making the capillary action between the under-soil and tilled soil difficult. It will work in

Fig. 26. Engine Breaking.

dry and in sticky soils better than the mold-board plow will. It is suited to a lighter type of cultivation than the mold-board plow is, and is frequently used in spring work.

When a plow turns more than a single furrow it is called a **gang-plow**. On the prairies much land is broken and cultivated by plows made up of a number of single plows and drawn by an engine.

They are suited to very large fields. Plows that are followed and held by the operator are called **walking plows**; those that are mounted on wheels to carry the plowman are called **riding** or **sulky plows.** The **subsoil plow** is a special kind of plow with a single chisel-like share that tears up the soil in the bottom of the furrow made by a common plow. It enables the soil to receive and retain additional moisture, and opens a deeper feeding ground for plant roots.

Harrows. The harrow is used to make the surface soil finer than it has been left by the plow, and to make it level and smooth; to make dry mulches on fallow land and on young crop, and to destroy weeds. The common kind of harrow is the **spike-tooth harrow,** which consists of a series of teeth set in a steel frame, and generally capable of being set by means of levers at different angles to tear or pulverize the soil. It is sometimes called the drag harrow to distinguish it from the disk harrow. The **disk harrow** is in general use where new land is being converted to cultivation. It cuts the sod and pulverizes the soil so that it fills the furrow seams and corrects the open texture of rough sod plowing. This helps in the rotting of grass that is turned under. It is used in the fall to break the surface of hard stubble land immediately after cutting. By this means continuous evaporation is stopped, the land is in better condition for the

covering of stubble by plowing, or if not plowed, the surface is roughened to catch fall and winter moisture. It is often used instead of the cultivator in the preparation of land in the spring. Disks of twelve to fourteen inches diameter do better work in soil fining and mixing than larger ones do, though the draft is heavier.

Other kinds of standard harrow are the **acme harrow** and **spring-tooth harrow,** which aid in the cutting, tearing, and pulverizing of soil. Home-made implements which aid in the smoothing and fining of the soil, particularly after seeding, are the **planker** and the **brush harrow,** both of which are quite useful in bringing about what is sometimes called the loose compactness of seeded ground. For the special work of weed destruction the harrow is extensively used. The drag harrow will destroy a good many seedlings by tearing them loose and leaving them on the surface to dry. The disk cuts deeper and stirs the soil much more than the common harrow does and destroys weeds. Weeds, however, of the tap-rooted kind especially, require some kind of a cutting implement to destroy them. For this purpose some type of flat-footed cultivator is necessary.

Packing Implements. In many places seeding operations are followed by the use of the **roller** to break the small clods on the surface, and to compact and warm the immediate surface in order to secure quick germination. Its use applies to moist

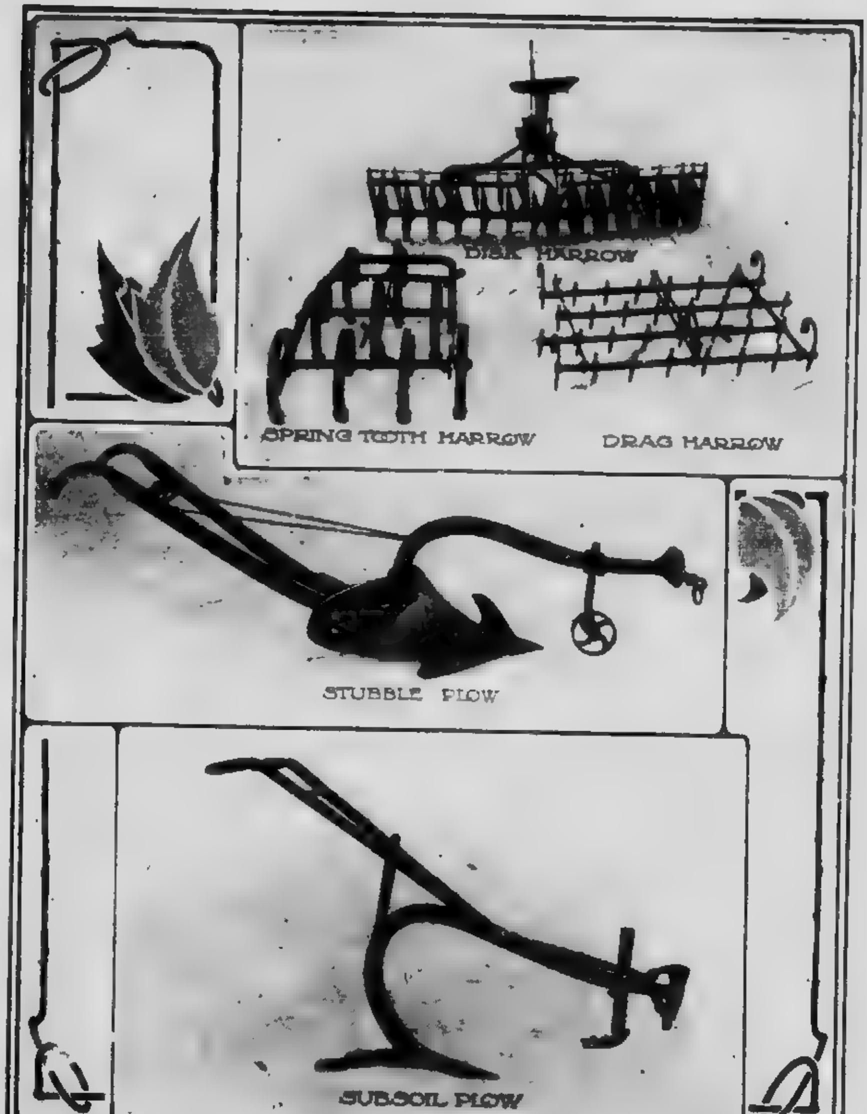


FIG. 27. IMPLEMENTS OF TILLAGE.

climates chiefly. In dry or semi-dry areas it is not an advantage, as it quickens evaporation and smooths and fines the surface so that it blows badly. In very wet land it causes baking. An implement called the **surface packer** (Fig. 8) is used to make firm the seed-bed after sowing in areas not subject to heavy precipitation. It consists of a series of metal wheels set on an axle but with the rims notched so that it presses through the soil rather than completely over it. This leaves the soil compact, but with the surface still broken so that it cannot be robbed of fine soil by the winds. The **subsurface packer** is built up of wedge-shaped wheels resembling a combination of two disks placed with their concave sides together. It is intended to compact the seed-bed some distance down, especially where the texture is very open, due to undecomposed stubble and other organic matter or to general lightness of soil.

EXERCISES

1. Examine a plow so as to know the following parts and their uses: beam, share, point, mold-board, landside, heel, coulter, rolling-cutter, jointer, and beam-wheel. 2. What are back-furrow, dead-furrow, and a land? 3. Of what injury are kinks and breaks in a furrow slice? 4. Whether would you choose May, June, July, or August for breaking prairie sod and for what reason? 5. Of what use is the packing of a garden bed after the seeds have been sown? 6. What are the losses and the advantages, if any, in stubble burning?

CHAPTER XV

DRAINAGE

Surface Drainage and Underdrainage. Even in countries of moderate rainfall there are areas that have to be freed of surplus water. Sometimes large areas are covered with water that can be removed. In such cases drainage is land reclamation, and, according to the extent of the work, may be a national or a municipal undertaking. On individual farms reclamation work may go on on a smaller scale. Often a little work may change a considerable part of a farm that is covered with standing water into arable land or hay land. The work is done by surface ditching. No elaborate plan or careful, detailed construction is necessary. It is simply a case of lowering the water level at a point where it can be done with least labor. The gravitational movement of water itself tends to make natural channels, by which the water moves towards the ultimate drainage basins of the globe. The work of surface drainage, however, is important, as it increases the productive area of the earth.

Underdrainage is a different kind of work. It is undertaken generally to bring about a different condition in the soil, and so is closely related to

tillage. It is a branch of soil management, and this is why it is generally discussed along with tillage. It is an expensive kind of improvement, and is not common in areas where land is cheap.

Objects of Drainage. The uses of drainage are as follows: (1) To make soil firm enough to permit of its being worked. (2) To admit air. (3) To increase the warmth of soils. (4) To remove an excess of soluble salts.

Drainage and Tillage. The operations of the farm, such as spring tillage, crop cultivation, and harvesting, are sometimes held back by a wet condition of the soil. It is not, as a rule, any advantage to work soil when it is wet, especially clay soil, but as soon as a farmer can get on the land, and can carry on light surface tillage, he is by this means aiding surface drying by opening the soil to the air. If either surface drainage or underdrainage will make earlier sowing possible, it is an advantage. It may still be inadvisable to seed land that is only dry enough to put horses and implements on, because the nearness of free water may keep the seed-bed cold. The progress of evaporation of water near the surface itself will have this effect. Usually, however, if the soil is dry enough to work, it is warm enough to seed.

Drainage and Air. The importance of water in plant growth has been shown in our plant studies. It has what the plant physiologist calls both

functional and constituent value, which means that it aids plant growth and it is also a part of plants. The water that passes through the plant has been shown by experiment to be four or five hundred times the weight of the dry matter of the plant and about seventy-five to ninety per cent of the weight

FIG. 28. APPEARANCE OF VEGETATION IN UNDRAINED LAND.

of the green plant is water. In spite of all this, we may have too much water in the soil. We must have air as well as water in the soil to have plant growth. If land is water soaked, plants may even wilt and die from root suffocation. We need air and warmth in the soil for the dissolving of plant food and for the sustaining of the life of the bacteria in the soil. Air is a condition to the

activities of the roots. The water itself which falls on the land brings down into the soil fresh supplies of oxygen from the air. If the soil is already filled with water, the fresh water just runs off the surface.

The increase in the depth to which air penetrates increases the volume of soil within which the root system of plants may develop and feed. Thus, the removing of water really makes more water available. Plants that grow on swamps or marshes are always shallow-rooted. If the water level is lowered, the roots follow the air downwards. The roots of grass and grain crops in well-drained, porous soil, commonly penetrate to a depth of two or three feet, though the bulk of the root system is near the surface.

Drainage and Warmth. Water is a poor conductor of heat. If land is saturated with water, it does not warm up in the sun like well-drained land does. The water of a lake is of a lower average temperature than the sand of the shore in the growing season. Soil does not warm up in the spring until the air gets into it. The fermentation processes, which can go on in the soil only when it is ventilated, warm up the soil. As root activity increases with the increase of warmth in the soil, the warming of the soil is directly promoting growth.

Drainage and Alkali. In the passing of water through the soil, some of the soluble matters, or salts, as they are called, are taken with it. The condition

of sea water is the most common and striking example of the removal of soluble salts from the land by drainage. This means a loss of plant foods.

On the other hand, if the land does not drain, these salts in some places accumulate on the surface of the soil. They are dissolved in the first place by rains, and washed a little way into the soil, and return again in the water by capillary movement. As the water evaporates, they are left on the surface, usually as a white incrustation, but not always. We have both white and black alkalis. This condition occurs also on dry lands, where there is not enough precipitation to make any free water in the soil, or it may occur on the borders of sloughs, the water of which is held up by hardpan not far below the surface. The water of such sloughs is sometimes injurious to stock. There is no gravitational movement of water away from these places, but only a return capillary movement and evaporation.

This gives rise to what are called **alkali lands.** They are not so much a particular kind of land as a particular condition of land. They will not support vegetation, because the soil solutions are too strong for the plants. They cause the plant to lose what cell sap it has instead of gaining soil water. Improvement is secured by drainage, or by the breaking up of the hardpan. On dry lands, the introduction of irrigation, which is a combination

of watering and draining, usually does away with the trouble, but irrigation without effective drainage makes the alkali condition worse.

Construction of Drains. Surface drains may consist of furrows made by the plow, or of channels both wider and deeper, made with the additional help of the scraper, or of more elaborate ditching machinery. Where the ditches are shallow, the sides are sometimes made to slope so gradually as not to interfere with the working of mowers and other machinery. They should be kept free from abrupt turns, and the sides should be sown to grass, as weeds develop readily along ditches. A modified type of surface drainage is secured by the dead-furrow in fields that have been plowed in narrow lands. Where the slope of a field is in a single direction, this plan works well.

Underdrainage requires more elaborate construction. It is usually secured by factory-made tiles of a diameter from three inches up. Water enters the tile through the crevices between the tiles. Lateral branches should generally be made of smaller tile than those of the main canal, and the laterals should enter the main drain at such an angle as to avoid cross currents. The work of laying out a system of underdrainage requires the use of the level in the first place, to determine the fall of the land, and to fix depths and grades. The fall should not be less than two

inches in a hundred feet, and the bottom of the drain in which the tile are laid should be a direct and accurate slope. A fall or depression in the bed of the drain may cause the settling of sediment and the choking of the drain. The construction of underdrains demands expert direction and careful work. The depth of the drain is usually three or four feet.

EXERCISES

1. Why are flower pots constructed as they are? Conduct an experiment, devised by yourself, to test your explanation. 2. Why do weeds and crops grow so well on the margin of a ditch? 3. Why is steaming greater on plowed land than on undisturbed land in the spring? 4. What difficulties might arise with tile-draining in the Prairie Provinces on account of the deep penetration of frost and its slow thawing out?

FIG. 29. GOOD LIVING.

CHAPTER XVI

MOISTURE CONSERVATION

Prairie Climate. Both climate and natural fertility influence soil management. A supply of plant food in the soil, and moisture to carry it into the plant, are both necessary for crop production. Right conditions as to moisture are commonly regarded as part of fertility, but as either may be a problem without the other, they are better considered separately. In areas of liberal rainfall, such as the eastern parts of North America, the interest is chiefly in the supply of plant food in the soil. These are the earliest settled parts of the continent and in some places show an exhaustion of plant food substances. Heavy precipitation itself causes some losses. The central plain of North America, on the other hand, has a precipitation of from fifteen to twenty inches only, as against from thirty to sixty, and a climate described as extreme. Its winter temperature is low and its summer temperature is high. Its moisture evaporates rapidly. On the other hand, as it is recently settled, it has not had time to show exhaustion of its natural fertility. The conservation of moisture is of importance on

the prairie. It is a matter of special interest in special areas; for example, those under the Chinook wind, which causes very rapid evaporation.

Breaking. The general effect of breaking up the prairie has been to lessen the run-off and to convert the moisture that falls to the production of a heavier vegetation. The appearance of the prairie in some places is unfavorable to crop production, but the meagre crop of natural grass is not due to poor soil or to absolute dryness of climate, but to compactness and dryness of the soil in the absence of cultivation. As only a small fraction of the total area of the prairie has been brought into cultivation, there will be a good deal of land each year that will be plowed for the first time, and as the way soil is managed in a single year affects the supply of moisture, often for a couple of years, it is important that breaking should be properly done.

Both the time of breaking and the way the work is done must be taken account of. Two-thirds of the annual precipitation over the prairie areas comes in the months of May, June, July, and August. Breaking should be done early in the period of greatest rainfall. The rain puts the sod in good condition to turn, and the earlier it is done after it is fit to plow the greater will be the amcunt of rain received and held by the plowed soil. Where the breaking is late, there is considerable run-off and also considerable moisture used up in the rapid

spring growth of grass. The time of breaking thus influences the condition of the soil as to moisture after breaking.

The way in which the breaking is done has a good deal to do with the way the soil holds moisture. The best results will be secured from turning the furrow-slice completely over and having it lie close to the furrow-sole or under-soil. This keeps both the furrow-slice and the under-soil moist. If the sod is only half turned over, or if it is full of wrinkles and breaks, it dries out rapidly and the under-soil dries out also. The sod will dry but it will not rot. It has too much air and not enough moisture to decompose, and the grass will not entirely disappear until it is more completely covered in the second season. Breaking is commonly followed by packing.

Use of the Disk. Careful disking is necessary after breaking. The common drag harrow will pulverize and smooth old land, but it has little effect on sod. The disk is a heavier implement, and its weight helps to compact the breaking, but its chief work is to cut the furrow-slice and pulverize the soil at the same time. It works best following the direction of the plowing and runs the loose soil into the furrow seams. As the two sections of the disk throw in opposite ways, the land can be kept level by overlapping a half at each turn. Disking should follow plowing immediately. What is plowed

each day should be disked the same day. The work is more easily done on the new furrow, and drying out is prevented by promptly compacting the soil. Many of the traction plowing rigs have a disk attachment which saves both time and moisture.

Later Plowing. Usually breaking is not very deep. It is sometimes as shallow as three inches, but a furrow as thin as this consists of a large proportion of grass and grass roots. It dries out quickly and has not enough soil on the upper side of it from which to develop a mulch. Five inches is a better depth, and some prefer to set a lower depth at the first plowing, but it requires good power to break land deep. It has been found satisfactory in practice to break deep enough to rot the sod fairly well and to make the second plowing or backsetting, as it is called, a couple of inches deeper. This will still keep the sod covered after the second plowing and will increase the loose soil. The depth should be increased to nine or ten inches in later plowing.

The right method of dealing with new land to bring it into good condition of **tilth**, as it is called, is the best method of conserving moisture, and this is true of tillage generally. The steps that have been followed in the preparation of new land have had three objects: the rotting of the sod, the fining of the soil, and the lowering of the depth of the

tilled soil. The rotting of the sod, or the changing of the vegetable material, such as grass and roots, into humus, which makes it a real part of the soil, has corrected the open texture of the soil, by which evaporation has been checked. The lowering of the plow has increased the capacity of the soil to let moisture down, and the pulverizing of the soil has increased the capacity of the volume of tilled soil to hold moisture. The finer the soil, the greater the surface area of the soil particles, and the greater its capacity for holding water. Clay, which is the soil made up of the smallest particles, has a pore space which makes up fifty-two per cent of its total volume when it is in a fine state of division, while coarse sand has a pore space of about thirty-three per cent. It is clear that a given volume of finely divided soil will admit more water than a coarse soil. For this reason it appears to be an advantage to have any kind of soil in a fine state of division and to have the soil tilled to a good depth.

A good way to remember the capacity of these soils to receive water is to change the percentage into inches. A foot in depth of sandy soil has enough pore space to receive four inches of precipitation, and a foot of fine, tilled clay over six inches. A soil in properly drained field condition, of course, does not contain this amount of moisture. It should not be filled with water. The moisture just covers the soil particles with a film and there

are air spaces between, but the finer the soil the greater the surface space there is to be covered with film moisture.

The main thing to remember is that the soil should be fine and the plowing should be deep. In an easily worked loam a depth of nine or ten inches is possible. Below this the depth of loose soil can be increased by the use of the subsoil plow, but as the rainfall does not all come at one time the ordinary plow will loosen the soil deep enough to take up the moisture as it comes. Besides this, the packing of the soil is often necessary, and it is hard to compact the soil to great depth. The objection to turning up poor under-soil by deep plowing does not commonly apply on the prairie, as the difference between the top soil and under-soil is not great.

The Surface Mulch. The two fundamental points in moisture conservation are to get the moisture into the soil and keep it in. We have seen that deep plowing and fine reduction of the soil are necessary to give the soil a high moisture-holding capacity. The next thing is to save the moisture for the use of the crop. There is usually very little loss of moisture by free underdrainage. The problem is to keep the soil from loss of water by capillarity. The average amount of water required to grow a ton of dry matter of representative farm crops, such as grain, hay and potatoes, has been shown by experiment to be four hundred and fifty

tons, which figures out to a rainfall four inches in depth, and for two tons the amount would be twice as great. Other experiments have shown the water required for different yields of grain. A twenty-bushel wheat crop requires six inches of water, a thirty-bushel crop nine, and a forty-bushel crop twelve. Wheat requires more for the same yield than oats or barley. The water spoken of here means effective water, that is, water that actually passes into the soil and becomes available to the roots of plants.

Evaporation. The surface mulch is used to make the rainfall available. The rains settle into the soil and moisten it for five, ten, or fifteen inches down. The soil particles are surrounded by the delicate films, and these are all held together by attraction for each other, apparently all trying to draw together as the molecules in the drop of water. When we speak of a molecule we mean the smallest division of which any substance may be capable. The point at which moisture is dissipated is at the surface of the soil. The moisture at the surface is a free surface that the sun and air can get at. The heat causes the molecules of water to stir about just as the heat under a teakettle does. They collide with each other and are thrown apart into the air as vapor. The heat has freed them from their fellows and has given them wings besides. This is evaporation. Other molecules come from within

the soil to take their places and to share their fate, for a movement at one point affects the whole moisture content of the soil. The rate of evaporation is affected by the condition of the air. If the air is very dry, evaporation will be rapid; if it is saturated with vapor, evaporation will be slow.

Maintaining the Mulch. The soil mulch is a layer of dry earth which prevents the exposure of a free surface of moisture to the sun and air. It shuts off the direct rays of the sun and it does not steal any moisture itself, or at least very little. The little moisture particles have greater attraction towards each other than they feel towards a dry soil, so they remain and keep the soil moist under the blanket of dust. Once the blanket becomes moist, as it does by a fresh rain, then the supply below joins with that above and the sun and air begin over again to drive the moisture particles off the surface into the air. The farmer has to check this. He cannot hang the dust blanket out to dry, but he can put the harrow on it and jostle it about and free its moisture, just as moisture is freed from a blanket on the line, and he cannot get good results in drying until the heat has wrung some of the moisture out of the surface. If he begins too soon the blanket still remains wet and loss by capillarity continues.

The keeping of a dust blanket on the soil in places where the rainfall is not heavy, say below twenty

FIG. 30 HEADS AND FACES.

inches, applies to all sorts of cultivation. After the farmer has disked his breaking, and more particularly after back-setting, he uses the drag harrow frequently to make a dry mulch. After he has harvested his crop, and even before he has moved his grain stooks, he uses the disk to break the hard surface of his fields. When he summer-fallows his land

FIG. 31. DISK FOLLOWING BINDER.

to get two years' moisture for one year's crop, he has to restore the dry mulch on his land after every rain, and he even harrows his young crop up till it is five or six weeks old to keep a dry surface and so drive the moisture into the roots of his crop. He also works the soil between his rows of potatoes, roots, and vegetables to save moisture as well as kill the weeds, and he does the same thing with his alfalfa when he grows it in rows to get good, strong seed.

The best depth for a mulch is about three inches. As the mulch consists of the surface soil it means that the best soil is out of use for the plants and too much of it should not be used in this way. Mulching for cultivated crops should be more frequent early in the season than when the crop is approaching maturity in order to kill weeds and ventilate the soil. Late mulching disturbs the root system which tends to work towards the surface late in the season.

Humus and Moisture. We found in our soil studies that all soils have not the same capacity for holding moisture. The best soil for this purpose is humus and the greater proportion of humus a soil contains the easier it will be to keep it moist. The soils in the driest parts of the prairie are generally light, easily worked soils and they need humus. The ordinary sources of humus are stubble, manure, and green crops. Stubble should not be burned. It should be worked down with the disk before plowing to have it cover and rot well. Manure should not be allowed to waste and rot around the stables, but should be spread on the land fresh and plowed down when it becomes wet with the rain. The best green crops to plow under are the leguminous crops, as they are rich in nitrogen. They should be allowed to grow past the flowering stage and should be carefully turned under to secure thorough decomposition.

Breaking of Brushland. All parts of the Prairie Provinces do not require the same care in moisture saving. Though the precipitation is not heavy any place, the country covered or partially covered with scrub does not lose its moisture by evaporation as easily as the bare prairie does. High winds are not so common in the northern parts of the prairie as in the southern parts, and the humus content of the soil is greater owing to the decay of a heavier surface growth. In breaking such land it is usual to plow it only once the first season, but to plow it deep so as to get below the roots and to follow the plow by the disk and packer. It is common to grow two crops before turning the land up again, in order to give time for the decomposition of the coarser material turned under, the preparation of the soil for crops being done by the disk.

EXERCISES

1. Explain the difference between precipitation and rainfall. 2. Discuss the suitability of wheat, peas, turnips, and trees for semi-arid lands. 3. What kind of subsoil is best in an area of limited rainfall? 4. Give examples of garden mulches. 5. Why should seeding on dry land be thin? 6. Is dry farming an extensive or intensive system? Is it more diversified or less diversified than farming in humid areas? 7. Give as many reasons as you can why root crops should be frequently cultivated. 8. What is meant by watering the garden with a rake?

CHAPTER XVII

DRY FARMING

The Meaning of Dry Farming. Dry farming is the name given to a system of soil management in areas where the annual precipitation is not considered sufficient for the production of profitable crops, except by special care of the moisture that falls. It is not farming without moisture. This is not possible. On this account the term does not accurately describe the system, but no other term has been able to displace it. It seems to be a good term when the system for which it stands is set over against irrigation farming. Irrigation farming is farming on watered lands, while dry farming is farming on unwatered, or, comparatively speaking, dry lands. It is sometimes described as the method of cultivation followed in places where the annual precipitation is under twenty inches, but the absolute amount of moisture that falls does not alone determine how soil should be managed.

A great many other things may be working either with the farmer or against him in his effort to make the moisture that falls effective. If moisture falls on a rich, humous soil, with a clay subsoil, it will be of greater use and effect

than it will be falling on light, sandy loam with a gravelly subsoil. The vegetation going with these different types of soils increases the difference between them. A heavy vegetation will shade the ground from the sun and, to some extent, check air movements, and so check evaporation, while the opposite condition will result from scant vegetation. The occurrence or absence of winds is also important. Perhaps the most important natural influence in making moisture effective or ineffective is the time at which it principally falls. If the greater part of the moisture falls in the growing season, as it does in the Great Central Plain, there will be less surface waste and less under waste than there will be in places where the greater part comes in late fall or winter or early spring.

The management of the soil has to be made to meet a whole set of conditions, not a single condition, such as that of precipitation alone. The same method of cultivation may have to be employed, whether the absolute precipitation is eight or eighteen inches. Where moisture is scarce from any cause, whether from light rainfall, light and open soil, high winds, or scarcity of rainfall in the growing season, the dry farm method has to be followed. It has really come to be understood as a system of storing moisture and of growing an average of less than one crop a year.

General Method of Moisture Saving. The method of moisture saving set out in a previous chapter must be understood to be a part of the dry farming system. Deep plowing and fine working of the soil are necessary to make it receive and contain moisture. The mulch must likewise be used at all times: to keep the moisture in newly broken land, to break the crust on young crop, to roughen the surface of the stubble field after the grain is cut, and to save moisture to the rows of potatoes, turnips, corn, and alfalfa. The humus content of the soil must also be kept up for the sake of moisture keeping as well as fertility.

Fallowing. Fallowing is a necessary feature of dry farming work. A rather common idea of the fallow is that it is a neglected piece of ground. Sometimes it is looked upon as a piece of land that is left unseeded in order to rest. The word fallow in origin means land that is yellow or bare on the surface from having no crop, or from not having been touched since the previous crop was removed. The fallow is unseeded land, but to the cultivator of semi-arid land it is not unplowed or uncultivated land. The fallow is a very active and interesting part of the farm.

The practice of leaving land bare has been given up in very moist countries. Where the precipitation is greater than can be taken up by the soil, the free water gets away by underdrainage. In settling

down through the soil, it washes out soluble plant food, which is a loss in fertility. If a crop is raised, ten or twelve inches of the water, perhaps, is used by the crop, and with it the plant food which it holds in solution. On areas of limited rainfall, on the other hand, there is little loss of plant food by leaching. The water settles down from a few

FIG. 32. ALFALFA IN THIRTY-INCH ROWS.

inches to several feet, according to the quantity falling and to the character of the soil, but it remains capillary water, and so is available for plant use when required. It has been shown by experiment that water falling in one year can be stored and carried over to the next year by special methods of cultivation. Deep and fine cultivation of the soil increases its storage capacity and

provides a supply of water for deep settling into the under-soil. Surface mulching prevents its evaporation.

Good results cannot be secured on weedy land. The fallow must be a clean fallow. Volunteer oats, sunflowers, and other weeds are as thirsty as a regular crop. Even if they are not as thick, their roots spread out and seek for available water. The oats stool out, and the weeds are heavy, coarse weeds, that transpire rapidly. The fallow should be well cultivated and bare.

Time to Cultivate. Plowing in preparation for fallowing should be done in the previous fall, if the land is not so dry as to make it impossible, and the land should be harrowed, so as to lessen the loss of moisture from evaporation. It is not necessary to plow again in spring, unless the land has become packed with heavy rains. The disk will pulverize the land to good depth in early spring. After this, surface working with the common harrow will make a sufficient mulch, except in the case of weedy ground, which may have to be gone over with a cultivator. If the soil is fine to a good depth, a three-inch mulch is deep enough. The number of times to harrow is determined by the rainfall. It is necessary to harrow after every rain that goes deep enough to saturate the whole mulch, and so to establish by saturation the capillary contact between the mulch soil and under-soil. Harrowing should

Fig. 33. Last Year's Moisture for this Year's Crop.

Twenty-six bushels to the acre of No. 1 Northern Marquis Wheat harvested from a field of summer-fallow, in Saskatchewan, having only 1.6 inches of rainfall during the growing season.

be done as soon after a rain as the soil is in condition to make it possible to secure the result desired. If it is done too soon, the harrow hastens surface evaporation, but does not break the mulch from the under-soil; if it is left too long, evaporation may cause heavy losses of moisture.

Frequency of Fallowing. Whether a farmer fallows every other year, or every three or four years, depends on local conditions of soil, moisture, wind, etc., and most of all on experience. It is not always safe to figure on average rainfall. The farmer should always be ready for a dry year. It has been said that if the precipitation is above fifteen inches, once every three years is often enough to fallow, but if under fifteen inches, land should be fallowed every other year. It is at least safe to say, that in areas where the annual precipitation is only ten or twelve inches, annual cropping should not be attempted. This means that twice as much land should be cultivated as is sown to crop in a given year.

Fallowing and Fertility. While fallowing on lands with limited rainfall is done for the purpose of storing moisture, it has an important effect in liberating plant food. The warm, moist fallow is favorable to chemical changes and to the work of bacteria. The class of plant food made available is the class called **nitrates.** The vegetable matter turned into the soil contains nitrogen. In this form

it is called organic nitrogen and is not soluble. By the entrance of the oxygen of the air, with conditions of heat and moisture favorable, the nitrogen takes the form of nitric acid. This acid unites with plant food substances, such as lime, soda, and potash, to form what are called nitrates, which are soluble in water, and so are available to plants. This is the way the humus of the soil is used up, and we have to keep adding to it in order to furnish a very important class of plant foods. The good crop that comes from fallowing may be due to larger supplies of available plant food as well as moisture. Continuous fallowing exhausts plant foods. In a sense fallow land is resting, because it is not supporting a crop, but in another sense it is a very busy place. The name given to the activities by which nitrates are formed is called **nitrification.**

Fallowing on the heavier new lands of the brush country, where moisture is more plentiful, is not necessary for moisture conservation, though it is sometimes carried on in order to destroy weeds. On such fallow lands, catch crops of grain are sometimes grown for summer pastures.

Crops and Cropping. The crops grown on semi-arid land in the Great Plains area are the ordinary farm crops, such as wheat, oats, rye, and barley of the grains; alfalfa, timothy, brome grass, and rye grass for hay and forage; corn also for forage rather

than seed; potatoes, and the common field and garden roots and vegetables; small fruits, and to some extent, trees.

Grain Crops. Wheat is the chief grain crop, and the winter varieties are grown in some sections of the prairie. The establishing of a good root system in the fall is a shortening of the period of spring and summer growth. On the other hand, weeds establish themselves easily with winter wheat. The Turkey variety of winter wheat has proved so suitable to the upper Great Plains that it has improved in weight and kernel on the seed from Kansas. In spring wheats there is a tendency to introduce drouth-resisting varieties, such as durum or the macaroni wheats. Early maturing varieties of oats are chosen. The beardless and hull-less varieties of barley are preferred. Rye is a good crop for semi-arid lands, owing to its rather limited transpiration surface.

Seeding. The importance of choosing seed grain grown under conditions similar to those into which it is being introduced, is fully recognized. Home-grown seed should be used where the crop has proved successful. Seeding should be done as early as the condition of the soil as to warmth and moisture will permit, and the surface should be left rough and not rolled. Seeding should be three or four inches deep. Only about half the seed is sown on dry lands that is sown on

moist, black lands. Heavy seeding on dry lands exhausts the moisture of the soil before the crop is matured. On moist lands, on the other hand, heavy seeding, by the using up of moisture, promotes early ripening, and so is a safeguard against frost.

Forage, Roots, and Trees. Leguminous plants, such as the vetches and pea vine, are common on the prairies, which gives warrant for the growing of alfalfa, and considerable success has already been attained. Alfalfa is highly desirable on account of the great crops of fine hay it provides, as well as to maintain fertility through the work of the nitrogen-fixing bacteria, which find a home and workshop in its roots. Rye and brome grass do well. Timothy requires a stronger start in early spring than it commonly gets on semi-arid land. Corn for forage is a profitable crop. Potatoes do well under light seeding and thorough cultivation. Of roots, the sugar beet seems to be well suited to the climate, and other roots do well in proportion to the care taken in their cultivation. Shrubs and bush fruits do better than trees, but suitable varieties of trees are successfully grown for windbreaks and for decoration. They require careful cultivation at first.

EXERCISES

1. Make a study of precipitation by provinces in the Dominion of Canada. Mark on a sketch map the number of inches in each, and group them on the basis of having under

twenty inches, between twenty and thirty inches, and over thirty inches. 2. Make a study of the monthly precipitation at the point nearest to your home where records are kept, and find the monthly and yearly average over a period of five years. 3. Explain what is meant by saying that moisture is fertility. 4. Place a cube of sugar in a saucer, put a teaspoonful of water in the saucer, and observe the progress of saturation. Vary the experiment by putting on the surface of the cube as much finely pulverized sugar as it will carry. Observe whether or not the pulverized sugar becomes saturated as the loaf sugar does. Apply your results to soil treatment. 5. Conduct an experiment with small plots of the same kind of vegetables in your home garden, one of which is not cultivated at all, one of which is cultivated every two weeks, and the third every week during the first six weeks of the growing season.

CHAPTER XVIII

IRRIGATION

Purpose of Irrigation. Irrigation is the practice of applying water to land by artificial methods. The common idea of irrigation is that it is the application of water to lands that will not otherwise produce crops at all. Irrigation works are generally established on lands that have not been tilled, and the heavy production that has followed irrigation gives it the appearance of land reclamation. Most of the prairie areas, however, in which irrigation has been established have a good sod of bunch grass or other prairie vegetation, and would in all cases produce some crop. There are not many places entirely without moisture, and if there were such, they would probably also lack the soil qualities that would make crop production possible even if water were supplied. Irrigation cannot reclaim an absolute desert of pure sand. The purpose of irrigation is to give certainty to crop production and to increase its volume so far as these things depend upon the supply of moisture.

Irrigation for Both Dry and Humid Areas. As the amount of annual precipitation varies greatly even in the same country or section of a country,

the need of irrigation or the benefit of irrigation must likewise vary. In places with a precipitation of only eight inches annually irrigation would be practically a necessity for the production of annual crops. In places with a precipitation of over twenty inches it might still be a great benefit. In the former case irrigation would be desirable on account of absolute scarcity of moisture; in the latter case it would be desirable to correct the irregularity or insufficiency of moisture during the growing season. In such countries as China and Japan, as well as in Mexico, where irrigation has been practised for centuries, the annual precipitation ranges between twenty-three and fifty-one inches approximately. Meadows of timothy and other grasses are flooded in the south-west of England, and truck farms and gardens are irrigated from water distributed in overhead pipes in New Jersey, though the climate in both these places is distinctly humid.

Irrigation in Canada is limited to the three western provinces, British Columbia, Saskatchewan, and Alberta. Its chief use in British Columbia is on fruit lands and in Saskatchewan on grass lands. In Alberta three large enterprises have been carried out affecting an area of over three and a half million acres, a good part of which is capable of effective watering. In these provinces irrigation is not employed to make crop production possible, but to make it certain and better. None of the area in

which irrigation is established has a dry, or arid, climate, which is commonly described as a climate having under ten inches of annual precipitation. The term semi-dry, or semi-arid, is another word that is used to describe climate where moisture is scarce or scant. The term is applied to the climate of places having under twenty inches of moisture but over ten.

We should be careful in considering climate in relation to agriculture. Twenty inches of total moisture may be plenty in one place and not enough in another. If moisture falls chiefly in the growing season, as it does in the Prairie Provinces, more of it is available to crops than if the greater part falls in autumn or winter, and so becomes subject to considerable evaporation before the crop is ready to use it in consequence. A condition that affects the supply of moisture unfavorably is the occurrence of high winds. The Chinook wind carries away a good deal of the moisture from both snow and rain before it has had a chance to settle into the soil. It even wastes moisture that does enter the roots of the crop. When a hot, dry wind is blowing the crop about, transpiration is sometimes more rapid than the supply of soil water can stand, and so the plant is wilted and set back. It is the effect of the Chinook wind in the southern part of Alberta and the south-western part of Saskatchewan that makes irrigation an advantage.

FIG. 34. HARVESTING ALFALFA ON IRRIGATED LAND IN SOUTHERN ALBERTA.

Other Benefits from Irrigation. Besides making it possible to grow heavier and better crops where rainfall is light or irregular, irrigation has other benefits. The increase of moisture not only makes it possible to grow better grain crops, but it makes **a greater variety of crops** possible. Under irrigation heavy crops of forage and roots are grown which

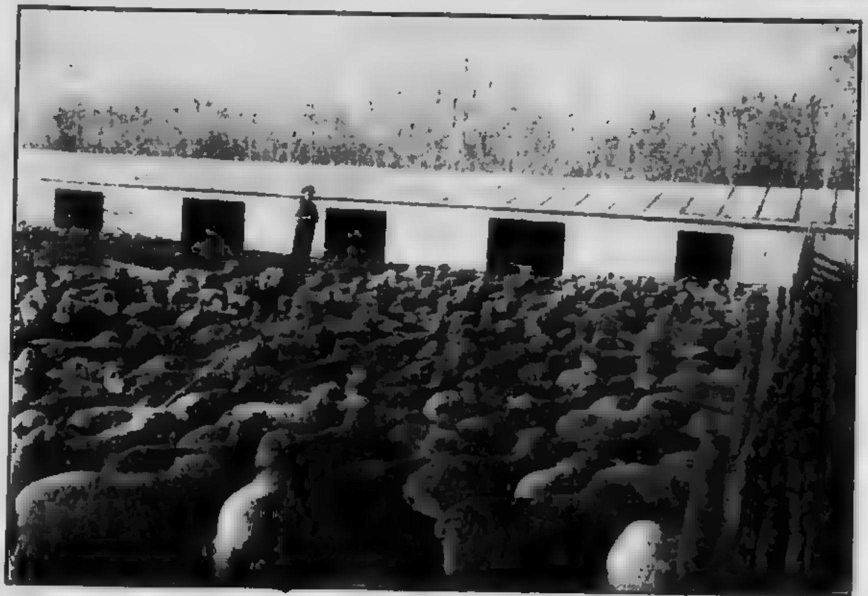


FIG. 35. THE FEEDING OF RANGE SHEEP.

make **stock-raising** possible. Stock-raising and special stock feeding help to **keep up the fertility** of the soil. Fruits and vegetables are common crops under irrigation. By investing more in water and in labor the farmer changes his system from **extensive to intensive agriculture.** Irrigation water contains plant food in solution and also carries sediment, both of which **increase fertility.** When

the irrigation of land is accompanied by proper drainage it **removes alkali** deposits, which sometimes retard the germination and even the growth of crops.

The Supply of Water. Water for irrigation is usually secured by damming a stream and leading the water out on to the land at a point where this is most easily done. The channel by which water is taken is usually called the **main canal.** The ditches which run out from the side of the main canal to distribute water are called **lateral ditches.** Lakes are sometimes tapped for a supply of water. Water is pumped from streams and wells and stored in reservoirs. This is a more expensive way of securing water than the gravity method is, but pays under certain conditions. Springs furnish water in small quantities. Flood and storm waters are sometimes held by the construction of reservoirs at the lowest point of a small basin, and the water is used for small field or garden plots. Irrigation enterprises generally take account of large areas. In Saskatchewan and Alberta the right to use water and construct irrigation works is secured by license from the Dominion Government, which is also charged with the duty of protecting the rights of the users of water.

Terms Used in Irrigation. By **duty of water** is meant the allotment of water for a given area. This is fixed by the government at a second-foot

for one hundred and fifty acres. A **second-foot** means a cubic foot of water each second over the irrigation season, which extends from the first of May to the first of October. Another unit of measurement sometimes employed is the **acre-inch,** which means the amount of water required to cover an acre of land an inch deep. Five inches of water over an acre of land would be five acre-inches and twelve inches an **acre-foot.** The need of a unit of measurement arises from the need of ensuring a sufficient supply to the users, and from the need of making a division of water among different users, as irrigation water is what is called a community utility. A unit of measurement is also some guide to the inexperienced irrigator. **Under the ditch,** or below the ditch, is a term used to describe the land over which water will flow from the ditch. The land on the opposite side is said to be **above the ditch,** though sometimes water is led along a ridge from which irrigation can be carried on on both sides. A whole farm may be spoken of as under the ditch, though every portion of it may not be subject to effective watering. The volume of the stream used expressed in second-feet is commonly described as the **head of water,** or **irrigating head.**

Methods of Irrigation. There are three general methods of irrigation: (1) By flooding, (*a*) from an open ditch, (*b*) by the check system. (2) By furrow. (3) By sub-irrigation.

The **flooding system** is the system most commonly used in Alberta and Saskatchewan. This is the system best suited to grain and forage crops, which are the crops most extensively grown. By this method the ditches are run at right angles to the direction of the slope of the land. The water is checked by damming until it rises to the rim of the

FIG. 36. THE USUAL METHOD OF IRRIGATING MEADOWS AND GRAIN CROPS.

ditch, and is then released at intervals by breaking the ditch with a spade. Some care and direction are necessary to secure uniform soaking after the water is freed. When the ground has been thoroughly irrigated in the section under this ditch a new piece is begun, served by the next ditch, which is from thirty to seventy-five yards lower down. One man will irrigate from two to ten acres a day, depending upon the surface of the land, the head of water, and the experience and skill of the irrigator.

A primitive type of flooding, called **wild flooding**, consists of diverting water and turning it on meadows to run for weeks or even months at a time, sometimes during the growing season for a hay crop, and in other cases during winter.

The **check system** is not commonly employed in Alberta, but is used to some extent in hay meadows in Saskatchewan. The check system is a system of dykes rather than of ditches. The water is served each way from a main ditch, and flows over the land until stopped by a dyke or levee, which backs the water over the area being watered. When one piece is done the water is freed, it enters another check and is held by another dyke. The word check refers to the blocks or units set out. Where the land is practically level these may be regular rectangular divisions; where the contour of the land is irregular the boundaries of the checks are irregular, and the system is said to be the **contour check** system, while the former is said to be by **rectangular** checks.

The **furrow system** is used in irrigating either field or garden crops grown in rows, such as potatoes, sugar beets, mangels, and also trees. The crop is planted in rows running up and down the slope of the land, and the water is allowed to run between the rows in sufficient quantity to soak the crop on each side. Water may be run in each furrow or in each alternate furrow. In the case of fruit trees

ring furrows are sometimes made around the tree to which water is led by parallel furrows running along the rows of trees.

Sub-irrigation is not practised in Western Canada. It consists of a rather elaborate and expensive system of tiles laid a short distance below the surface and filled with water. The water seeps from the joints of the tiles and works to the surface by capillary action.

Irrigation and Drainage. From what has been learned in previous chapters about ventilating the soil it will be readily understood that drainage is a necessary condition to successful irrigation. In irrigating land the water should be served rapidly to the land to a volume from six to nine acre-inches according to the needs of the crop and the character of soil. After the land is soaked it should be freed from stagnant water, so that the feeding processes depending upon air and moisture together can go on quickly. The same methods of cultivation employed in the dry farming system should be employed. With cultivated crops the land should be worked as soon after irrigation as the surface is dry.

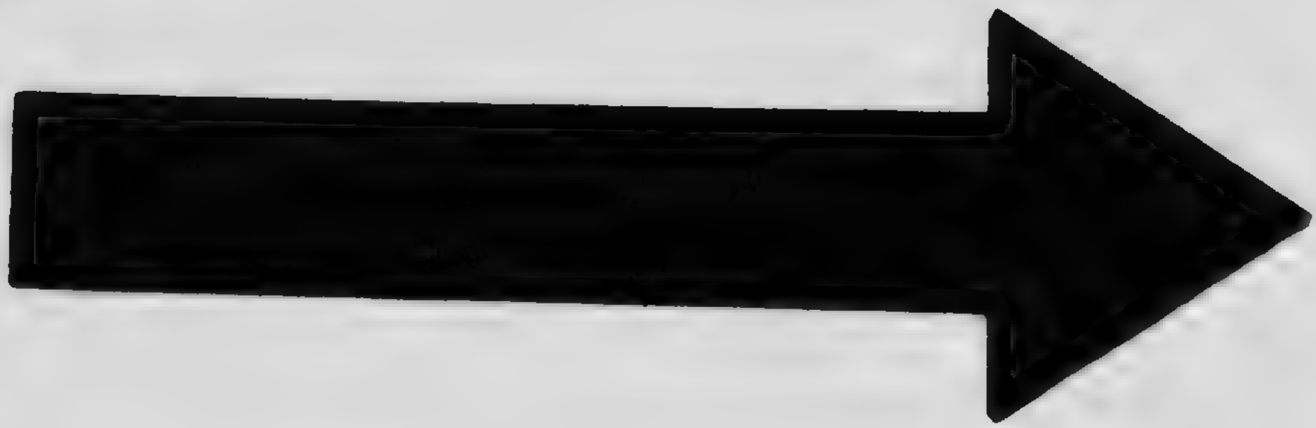
Time and Frequency of Irrigation. The time at which irrigating should be done depends upon the crop. Usually grain and forage crops are irrigated once and in the middle or early part of the growing season. Late irrigation keeps such crops growing

too long and they may suffer from frost. On the other hand, if the soil is in good condition as to moisture at seeding time, root crops require moisture chiefly when they are completing their growth, that is, when they are storing up starch in their underground parts. These general practices are subject to modification according to the obvious needs of the crop at a particular time or in a particular season.

The practice of irrigating land in the fall is rather common. Land is usually dry at this time, and during the season of winter there is little loss from evaporation, except at the immediate surface, as capillary action is stopped by frost.

EXERCISES

1. What is meant by saying that it is the business of the farmer to subdue nature? Give examples. 2. Does the snow lie from fall until spring in your district or not? Explain the good or harm from the conditions. 3. What operations of the farm are assisted and what ones are interfered with by a dry midsummer and fall? 4. Tell the good and the harm done by the Chinook winds if they prevail in your district. 5. What advantage has mixed farming over grain-growing alone? 6. Give as many reasons as you can why crops may become wilted? 7. Whether would you prefer to have four showers of an inch of rainfall each over a period of three weeks or one shower of four inches in an area of limited rainfall? Explain. 8. Which should produce the better garden crop, sprinkling or sub-irrigation?



PART IV—CROPS

CHAPTER XIX

CLASSIFICATION OF PLANTS

The Plant Kingdom. The plant kingdom has countless forms and types of life. An obvious feature of plant life is the difference in size of different kinds of plants as, for example, the forest tree on one hand and the moss on the other. Plants differ widely also according to their home, or habitat, as it is called. Water plants, desert plants, and garden vegetables have constant characteristic qualities and differences. Again, most plants are independent providers for their own needs and find part of their food in the soil; others live on their fellows. The same kind of plant also may show great variations according to locality. There is always some place where a particular kind of plant will do best, and though it may live and survive in another place it will usually be smaller or at least different. The same kind of plant may vary greatly even in the same locality owing to differences in light, moisture, shelter, or to competition with other plants for room and plant food. The great variety and multiplicity

Fig. 37. Rich, Conventional Decoration of Park Lanes.

of plants may be realized by the most casual observer in the forest or garden or on the lake shore. Though the variety is bewildering, it is scarcely possible to help seeing that the kinds of plants that have established themselves are such as suit the conditions. It is an interesting and profitable exercise to study how plant character fits the environment of the plant.

Plants Highly Organized. The botanist has established an order and system in the apparent confusion of plant forms. There is only one respect in which all plants agree. They all have the elementary constituent unit from which the body of every plant is built up, which is the plant cell. Some plants consist of a single cell, but highly organized plants have countless cells. This common property does not give us any basis of classification. A study of plants would be quite incomplete that did not take account of the most highly developed plants or, as we might say, the best developed plants, which are those that have special organs, such as the root, stem, leaf, flower, and fruit for special duties. It is among the most highly organized plants that variations seem to occur most easily.

How Plants are Classified. The botanist has sought out points of similarity and difference in the parts of plants such as to make it possible to arrange them in groups. This department of plant study is called systematic botany, and the classification

is said to be made on the basis of **form** because it takes account of the forms or kinds of root, stem, leaf, flower, and fruit. Another basis of classification is the **length of life** of the plant. All plants do not complete the cycle of life in a season as we are perhaps apt to think on account of the round of the seasons. Finally we have the agricultural classification which is based upon **use.** All of these systems are of more or less direct interest to the farmer.

Botanical Classification. All of the plants commonly grown on the farm or in the garden belong to one great botanical division called **seed plants.** The farm and garden plants are included in nine families. The latin names of these families are universally used, though they are also sometimes named by a common type plant. Two of these families are very important. The most important family is the **graminae,** or grass family, which includes all the cereals and grasses, such as wheat, oats, barley, corn, timothy, brome grass, etc. While these would fall into two classes, called grains and hay or fodder crops, in an agricultural classification, their botanical grouping is based upon their having similar parts. They are all fibrous-rooted plants and feed near the surface and so should not be sown deep. Thus their botanical form has some relation to their treatment. The detailed study of one member of the group gives us a key to the structure of all the rest. In botany

we make the acquaintance of types through individuals. It does not matter whether we start with the wheat plant or timothy. The roots are the same; the stem which is called a **culm** is hollow, but enlarged and solid at the joints; its leaves which surround the stem are **alternate**; the flowers are in **spikelets**, or clusters, or are condensed into a **spike**, and the flowers are enclosed in **glumes** and **pales** which become the chaff of the ripe plant.

Another important family is the **leguminosae**, or pea family. Its importance is due not only to the nitrogen in the plant itself, but to the work of the bacteria that make a home in the tubercles of the roots and fix free nitrogen from the air. It includes alfalfa, the clovers, vetches, beans, and pease. The family is the same as that of the wild vetch, and the members of the group can always be associated by their butterfly-shaped corolla and by their seed pods.

The group characteristics of the other families into which agricultural plants fall are not important agriculturally, but the common group names and familiar examples, including a few weeds, as well as useful crop plants, are given as material for those who wish to supplement agricultural study by botanical study.

Parsley family: parsley, parsnip, carrot, and celery.

Rose family: apple, pear, raspberry, and strawberry.

Mustard family: mustard, rape, cabbage, and radish.

Lily family: onion, hyacinth, and tulip.

Nightshade family: potato and tomato.

Aster family: sunflower, thistle, lettuce, and dandelion.

Gourd family: cucumber, pumpkin, squash, citron, and melon.

While the other three great divisions which reproduce from spores or by a simple method of division, rather than from seeds, do not include any of the cultivated field or garden plants except the mushroom, which is grown in a few places, they are important because they include the bacteria and fungi. We have learned a little about bacteria in our plant and soil studies. The fungi include, among others, such plants as the molds, mildews, smut, and rust, some of which give rise to very practical problems in crop-growing.

Classification on Length of Life. By the classification of plants on length of life we get **annuals, biennials,** and **perennials.** An annual is a plant that germinates, blooms, produces fruit, and dies in a season or year, such as oats, beans, peas, wild buckwheat, wild oats, and mustard. Some grains, such as winter wheat and rye, and some weeds, germinate in the fall and complete their growth in a year, but use a part of two seasons. These are called **winter annuals.** Biennials usually grow roots and leaves

FIG. 38. THE HACKNEY.

and store up food the first year and produce flower and fruit the second year. Examples are the parsnip, carrot, beet turnip, red clover, and white clover. Perennials are plants that live for three or more seasons, usually blossoming and producing fruit each year after maturity. Examples are trees, shrubs, most meadow grasses, alfalfa, couch grass, strawberry, dock, and thistle.

The chief value of a knowledge of the life habit of the plant has relation to weeds, but to some extent to grasses or to the making of grass mixtures. A knowledge of the nature and habit of a plant is necessary in undertaking to destroy it. A clean field may become dirty in a single season from a half dozen grains of mustard in the seed wheat because mustard completes its life cycle in a season and produces a lot of seed. e cannot afford to be ignorant of the habits of such enemies as mustard, the thistle, and couch grass.

Agricultural Classification. The agricultural classification of plants is the one in which we are directly interested. The grouping of farm plants or crops is a convenience for purposes of study. It does not include the whole plant kingdom, but only cultivated plants, and the whole list can be easily gathered and set together. It is plain that the classification will vary according to the locality in which crop production is being studied. Old settled countries, provided that they have moist climate

and good soil, will have a greater variety of crops than places where the soil resources have not been fully tried out and the climatic influences are not fully understood. Besides this, different plants may have different uses in different places or even on the same farm. Flax, while it is grown primarily for its fibre in most places, and is classified as a

FIG. 39. RAPE IS A HEAVY PRODUCING FORAGE PLANT.

fibre crop in most books, is grown wholly for its seed where linen manufacturing is not developed. Corn is both a grain and forage crop where it reaches its best development, that is, in the Central States; in the Central West of Canada, with less moisture and less summer heat, it is practically a forage plant only. While wheat, oats, barley, rye, and pease are grown primarily for their grain,

the straw is likewise used for forage and other purposes. Practically all of these grains are sown for forage, usually in mixtures. Root crops of the same name appear in both field and garden crop groups, but they are usually distinguished by the use of different varieties for stock and table food.

Any classification, however, is good and really scientific that arranges plants in groups according to a common idea, such as the use made of them or of their important parts, or such as a common method of culture, but only one basis should be used in any classificatio On the basis of the use made of its parts, rape, for example, is a forage crop, even though it has a close family relationship with such root crops as the turnip ad in some places is cultivated in much the same ay.

A useful classification of farm plants or crops would include:—

(1) Grain: wheat, oats, barley, rye, pease, and flax.

(2) Forage: timothy, brome grass, rye grass, blue grass, red top, alfalfa, vetch, millet, corn fodder, small grain fodder, and rape.

(3) Roots: turnip, carrot, mangel, beet, and sugar beet.

(4) Tubers: potato.

(5) Trees: poplar, ash, elm, birch, maple, and spruce.

EXERCISES

1. Select three plants of the same kind and in the same neighborhood and account for their differences in size or habit of growth. 2. Compare the leaf of the bean and of the cactus as to surface and as to density of structure, if both plants are available in your neighborhood. 3. What is meant by a plant being highly organized? Give examples. 4. With a double lens make an examination of one variety of meadow grass, and one of grain when in full bloom, and write a description of each. 5. Discuss the effectiveness of spudding in the cases of thistle and couch grass. 6. Make a list of the different kinds of forage that are used in your neighborhood. Collect samples of each. 7. What different uses are made of flax? 8. Write down in separate lists the crops of the farm that are summer foods and those that are winter foods.

Fig. 40. A Flock of Suffolks.

CHAPTER XX

CROP ROTATION

Meaning of Rotation. By crop rotation is meant a sequence of crops. When we speak of crop rotation, we must be understood to be dealing with the subject of cropping in relation to a particular soil area or piece of ground, or to a whole farm, which may include several crop units or fields. A sequence must likewise be understood to be an ordered sequence or system. Each crop succeeds the one before it for a certain reason or advantage.

Rotation and the Science of Agriculture. The first men of science who undertook to study plants in relation to the causes, sources, and conditions of growth were chemists, and they dealt almost exclusively with the substances in the soil that furnished food materials for plants. They gave themselves up wholly to investigations relating to **fertility,** or the supply of plant food materials in the soil. An analysis of the plant showed what substances it took from the soil, and the problem of agriculture was to keep from wasting these, or to add to them by artificial means. They made the use of artificial fertilizers popular.

The benefits of rotation were known practically and experimentally back in classical times. The scientists brought the light of chemistry on the question in showing that all plants do not use or require the same foods in the same proportion. Until quite recently, the chief reason given for the rotation of crops was based on this idea. A repetition of the same crop exhausts a particular class of foods. Conversely, a variation of plants preserves the balance of food materials in the soil. It is true that all plants do not use foods obtained from the soil in the same proportions, though they all must have the organic group of four, and the inorganic group of at least six elements. There are other things that affect the success of crop-growing over a series of years besides the supplies of plant food. Some plants put more back into the soil than others, the legumes among forage crops being the best example. Then there are questions of the moisture used or wasted in certain crops, the depth of feeding, the conditions favorable or unfavorable to the work of bacteria, and the variations in tillage for different crops. The **condition** of soil is as important as the supply of food materials.

Economy of Rotation. The question of rotation is determined by **economy.** We must understand economy in the large sense as profitable use rather than saving.

The advantages of rotation are given below:

(1) It avoids the exhaustion of particular foods. A thirty-bushel crop of wheat takes twice as much nitrogen and phosphoric acid from the soil as a thirty-bushel crop of oats, but as the average yield of oats is about twice as large as that of wheat, their effect on the land as crops is about the same with respect to these foods. On the other hand, a thirty-bushel crop of oats requires as much potash as a thirty-bushel crop of wheat, which means that the usual crop of oats takes out of the soil twice as much potash as the usual crop of wheat. It appears that even though these crops are a good deal alike, they vary considerably in their tax on the three kinds of food material that are hardest to keep up —nitrogen, phosphoric acid, and potash.

(2) It restores by one crop the losses made by another. The exhaustion of nitrogen is the chief cause of crop failures, so far as crops depend upon foods. Legumes, such as alfalfa and clover, add more nitrogen to the soil than they take away, and should have a place in a rotation embracing cereal and root crops, which use a lot of organic material.

(3) It makes a larger general use of the stores of plant food. Most fibrous-rooted plants, such as wheat, feed near the surface, while tap-rooted plants, such as alfalfa and the sugar beet, penetrate deeply into the soil.

(4) It changes the physical condition of the soil by varying the tillage. Grasses are not subject to cultivation after seeding, and grains to only a slight extent. Roots and potatoes are. Cultivation fines the soil. Summer-fallowing lowers the depth of tillage, pulverizes the soil, and keeps it moist. Cereal and grass crops bind the soil; cultivated crops leave it open to the work of winds and heavy rains.

(5) It restores organic matter. While cultivation uses up organic matter by making it available to crops, grass crops restore it by the accumulation of roots and stems in sod. Decomposed sod means not only fertility, but good physical condition.

(6) It promotes the activity of soil bacteria. This arises from such operations of tillage as result in making the soil fine and keeping it moist.

(7) It destroys weeds and insects. Grain crops are annuals. Many weeds, like mustard and wild oats, are also annuals. They grow and shed their seeds on the ground in a single season. They will appear in the next year's crop if it is the same kind. Cultivated crops and fallowing tear them out and they die on the surface or are buried. Grass crops choke them. The larvae of insects are destroyed by cultivation.

(8) It destroys toxic substances. Toxic substances are supposed to be organic compounds that are left in the soil by excretion from plants. An

FIG. 41. WESTERN WHEAT.

accumulation of these by the same plant year after year may react on the health of the plant. To the particular plant they are poisonous, though not to other plants. They explain what is commonly called "grainsick" land.

The explanation of the advantages of crop rotation will show, likewise, why a rotation should be a well-considered and systematic one. A particular crop should offset the one before it and prepare for the one which follows it, with respect to the use of plant food, the depth of feeding, moisture, kind of tillage, etc. It is clear that crop rotation is not, on the whole, a method of increasing fertility, except, perhaps, in the case of one special kind of crop in the rotation, or unless green manure crops, which are grown explicitly for putting something into the soil, are included in a rotation, and other manures and the waste from crops are also returned. On the contrary, it must be true that if a farmer is producing twice as much vegetation on the land as his neighbor, he is actually converting twice as much plant food to his use. He is using more fully the resources of the soil, but he may make partial restitution as he goes along, and it is quite possible that a scientific rotation may ultimately be arranged which will maintain without depletion the resources of the soil, but not without our taking steps periodically to put something into the soil without taking anything out.

Making a Rotation. It is not easy to set out rotations capable of being applied. They must vary according to the general system followed, or to the crops suited to the locality, to the demands of the market, and the tastes of the farmer. Under an extensive system of farming, such as is followed in areas of limited rainfall, effective rotation is difficult. The greater the variety of crops grown, the easier it is to increase total production with the aid of systems of rotation. Systems of rotation can be best studied by first classifying crops into cereals, grasses, legumes, cultivated crops (including fallowing), green manuring, and catch crops, and observing the following principles:

A rotation should contain representatives from different groups. Wheat is still the most important crop in Western Canada, and is a good crop from which to develop a rotation.

The conversion of organic material into humus by cultivation is a good basis for a wheat crop, which requires large supplies of organic material.

Oats are apt to run too much to straw following cultivated crops or fallow in a moist climate.

Barley may replace wheat in a rotation on well-drained land.

Legumes should be introduced frequently where they can be grown. If the soil is light they should be kept on the same land over a series of years if they are perennials.

Rich, black soils will stand cereals and root crops better than light soils will.

Wheat, oats, and barley all answer as nurse crops for grasses.

Alfalfa should be sown without a nurse crop.

Grain crops for fodder take less from the soil and leave more in it than threshed crops do.

Catch crops should have a place in a rotation for the sake of feed, fertility, and, in some places, to keep the soil from blowing.

In practice, rotations run from three to six years, but generally about four.

Where alfalfa is a successful crop, it should determine the rotation. It is a heavy producer, a soil improver, and is a perennial that does not reach its best production until the second or third year. Alfalfa requires a long rotation period.

EXERCISES

1. Give reasons for including the following in a rotation: potatoes, alfalfa, wheat, and pasture grasses. 2. Give reasons for including fallowing in a rotation. Is the fallow as necessary under a diversified system of farming as under a system devoted chiefly to grain-growing. 3. Arrange the following crops in the order of their desirability for what they return to the soil: potatoes, alfalfa, wheat, pasture grasses, and sugar beets. 4. Which is likely to succeed better in a dry year, oats or rye? Explain. 5. What losses may arise from a cultivated crop in a dry climate? In a moist climate?

CHAPTER XXI

GRAIN

The grain crops grown in the Prairie Provinces include the cereals, pease, and flax. Cereals are commonly defined as members of the grass family that are grown for their edible grains. The cereals are the most important of our grain crops, and of these wheat is the most extensively grown.

WHEAT

Uses of Wheat. Wheat is a crop of universal use and great antiquity. It is spoken of in the literature of five thousand years ago. Its chief value is in the flour it furnishes for human food. Wheat flour is superior to rye or barley flour, and its use stands for a good standard of living, such as belongs to an advanced civilization. Wheat is usually the first crop grown in newly-opened areas in the Western Hemisphere. Bread is called the staff of life, and wheat furnishes large supplies of food with small demands of labor. It is likewise the chief crop grown in what are called bonanza enterprises, as it is a machine crop. In older settlements it becomes displaced by mixed farming

Fig. 42. American Standard-Bred Horse

crops, as it runs out from soil exhaustion. Canada and the Argentine are two countries in which wheat growing is expanding at present.

It is an international commodity. Great Britain is the greatest consumer of wheat grown in other countries, and imports about two hundred million

FIG. 43. SUNSHINE AND HARVEST.

bushels annually. The price of wheat in Great Britain largely determines the price all over the world. The price of wheat is not likely to go down, as population is constantly increasing and unsettled land steadily decreasing.

Wheat is a good stock food, but its cost compared with other grains limits its use for this purpose. Its use for stock is limited to the poorer grades

and to by-products such as bran, shorts, and middlings. The germ is a by-product of wheat that is used as a breakfast food. Sometimes a flour is made from grinding the whole of the grain together. This is called graham flour. The straw of wheat is the least valuable of all the straws for rough feed except rye, but the chaff is relished by cattle. Emmer and spelt, which are members of the wheat family and which do not shed their hulls in threshing, are used wholly for stock food, but are not grown to any extent in Canada.

Kinds of Wheat. A convenient classification of wheat is based on the time of sowing. This gives us **winter wheat** and **spring wheat**. This classification is based on characteristic habit and differences in cultural methods. Wheats are sometimes classified on the basis of hardness, generally in connection with commercial grading. Hardness depends in some cases on the kind of wheat, but likewise on climate and perhaps soil, rather than upon variety alone. The distinction between hard and soft, however, has associated with it important differences in use. Hard wheats are bread wheats; soft wheats are biscuit and pastry wheats. One very hard variety, called durum wheat, is used for making macaroni. Wheats are also classified sometimes on such unessential qualities as color, chaff, or the presence or absence of awns.

Climate and Soil. Wheat has a wide climatic distribution. India and Russia, for example, are both wheat producing countries in the Old World, and Kansas and Canada in the New World. The best wheat, however, is produced in countries with cold winters and with the growing season rather cool and moist and the ripening season hot, dry, and with long days of bright sunshine. Where the growing season is protracted, the cells of the grain are completely filled with starch, and the grain is soft; where the growth is sharply checked by good ripening weather, the proportion of starch is less and of gluten more, and the kernel is harder and darker. It is gluten that gives the sticky quality to dough, and is the gummy substance left after the starch is dissolved out of wheat by chewing. A wheat that is rich in gluten makes what is called a strong flour.

The best soils for wheat are clays and clay loams, but the fertility must be kept up for heavy yields. Winter wheat requires heavier soil than spring wheat. It stands the winter best in such soils. Differences in soils are not thought to influence the quality of wheat as differences in climate do, but heavy, new, black land that holds its moisture late in the season is known to produce softer wheat than land that has been opened and warmed by tillage.

Culture of Wheat. All plants profit by thorough tillage of the kind suited to the climatic and soil

conditions, the chief points of which on the prairie are:—deep plowing to increase the soil depth for receiving rain and for the easy penetration of roots; the fining of the soil to increase its moisture-holding capacity and to increase the surface for root feeding; and frequent surface cultivation to prevent loss of moisture from surface evaporation.

Wheat, however, is a shallow rooting plant, and where plowing is done in immediate preparation for wheat it should be shallow. This allows the roots of the plant to spread out over the furrow-sole, which is somewhat compact and is the point at which capillary moisture is chiefly secured, and the roots can still be near the surface and the air. Some of the longer roots, of course, penetrate to a much greater depth, but not the general root system. Where land is plowed in the fall in preparation for spring wheat it is plowed deep, and the cultivator or disk is used to fix the depth of loose soil in the spring. Fall wheat sowing is usually preceded by fallowing. If fall wheat is sown after another cereal crop, such as oats or another crop of wheat, the soil is usually too dry to give the grain a good start in the fall. Where two crops of wheat come in succession, the second crop should be heavily manured. Wheat is not subject to cultivation after sowing except to break the crust on fall wheat in spring or to maintain for a time a mulch on spring crop in dry areas.

Stooling or Tillering. It is important to know about the habits of the wheat and other cereal plants. When the wheat comes up first it has three roots. These are only temporary roots. After the shoot has grown a little, other roots, generally six or eight in number, start from a node or joint below the surface and the others gradually die. The stem system also expands. Buds appear on a node and these become stems also. This stem expansion is called **stooling or tillering.** Some kinds of wheat produce more tillers than others, but their development is influenced chiefly by thin seeding, plenty of moisture, and good soil. The amount of seed sown in semi-arid lands is only about half of what it is on moist lands. If sufficient moisture comes, the crop will thicken by tillering; if it does not come the smaller number of plants will still mature satisfactorily. Shallow seeding is thought to increase tillering, but the depth of seeding should be regulated by the distance below the surface of sufficient moisture to promote rapid germination.

Fall wheat requires a good start in the first season. If it does not establish a strong, permanent root system and stool well before winter frosts have checked growth, it will not stand the winter very well. The establishing of a good root system in the fall in preparation for spring growth is one advantage of fall wheat in dry areas. On the other

hand, where moisture is scant this stand cannot easily be secured except on fallow, which means two years' work for one year's crop. Fall wheat also brings weeds, particularly if it is partially winter-killed. Spring wheat is grown to a much greater extent than fall wheat on the prairie.

FIG. 44. HEADS OF WHEAT FROM SEAGER WHEELER'S TRIAL PLOTS.

Harvesting. Wheat should not be allowed to become dead ripe before cutting. Some varieties shell badly in handling, and all more or less when very dry. It should be cut after the milk and dough stage of the kernel when the grain is well filled but soft enough to be readily indented by the thumb nail. The general appearance of the straw

and crop should be rich yellow. Wheat is commonly harvested with the selfbinder by horse or gasoline power. In large farm enterprises the header is sometimes used, which leaves practically all the straw on the field where it is of most use if it cannot be converted to better use by live stock.

Seed. Seed should be pure and should be of good quality. By **purity** is meant freedom from weed seeds, from other kinds of grain, from other varieties of wheat, and from smut. Good **quality** is determined in a number of ways. The grain should be well matured and should be free from injury by frost, or from disease such as rust. It should be large, plump, and heavy. Good milling wheat is hard, translucent, and bright in color. Seed grain of all kinds should be tested for vitality, and should be treated for smut before being sown if subject to smut.

OATS

Uses of Oats. Next to wheat, the most important grain crop grown in Western Canada is the oat crop. The grain is used in the form of rolled oats or oatmeal for human food, but its chief use is as food for live stock. The same interest is not attached to it commercially as to wheat, but on account of its use for live stock the progress of oat-growing indicates the progress of mixed farming. On account of the high protein content of

the grain, it is an excellent food for young stock. It is fed whole to horses and sheep, and ground to cattle and hogs. It is commonly mixed with other grains for hog feeding. The straw is of considerable value for roughage when supplemented by better feed.

FIG. 45. GROWTH FROM TWO SAMPLES OF OATS

Illustrating the difference in the energy of germination. The seed planted on the left germinated 81 per cent in 14 days, but only 12 per cent in 6 days, as shown above, while the other sample germinated 93 per cent in 6 days and 99 per cent in 14 days.

Kinds of Oats. There are two common varieties of oats, distinguished by the panicle or head. The **open panicle** is the more common. In this variety the grain is arranged on the stem in spreading whorls. In the **side panicle** variety the grain is all on one side of the stem. Oats differ as to color, being white, black, or yellow, white being most common.

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FIG. 46. ROOTS OF THE MULTIPLIER PEA FROM INOCULATED AND FROM UNINOCULATED SOIL.

Climate and Soil. Oats have a rather wide distribution, but do best in a cool, moist climate. Oats grown in warm countries are longer and have thicker hull and poorer kernel than they have in cool countries. Oats commonly weigh from forty to forty-eight pounds per measured bushel in the upper prairie sections. They do best in rich loams, but will produce fair yields on all but very light soils. They require a soil of good moisture-holding capacity. On extremely rich soils they are apt to go to straw and to lodge. They are not as satisfactory for a nurse crop as either wheat or barley on account of their coarse straw, heavy leaves, and late ripening. The same culture methods apply to oats as to wheat, but they will do with less careful preparation. They should be sown early, so as to get a good growth while the weather is cool and so that they will ripen early.

BARLEY

Uses of Barley. Barley is an ancient crop, and until the sixteenth century was perhaps used for bread more than wheat was over the whole of Europe. It is still used for bread in many parts of Europe. Its chief uses in America are for malting and for stock-feeding, but a little of it is used whole, stripped of the hull, for human food. The common varieties grown in Western Canada are the **six-rowed**, which is a feeding barley, and

the **two-rowed**, which is used for malting. The name arises from the number of rows of grain on the head. Barley is not commonly fed alone to any kind of stock on account of the amount of ferment it contains. The malt sprouts and brewers' grain, which are by-products of malting, are extensively used for stock-feeding. The straw is not very good for feeding on account of the trouble the awns cause in the mouths of live stock. Hull-less barley is a kind in which the hull is separated from the kernel in threshing. It is used for stock-feeding.

Barley has about the same climatic adaptation as wheat, and requires the same treatment and soil. It does not do well on poorly drained soil. It is preferred to any other cereal as a nurse crop on account of its short straw and early ripening. Barley is subject to two kinds of smut, just as wheat is, and the seed requires the same treatment. It is also attacked by rusts similar to those affecting wheat and oats. It does better on alkali lands than wheat does.

RYE

Rye is an important crop in Western Canada. As a grain it is not distinguished by a standard use such as wheat for flour, oats for horses, and barley for brewing, though the grain is useful in a number of ways. It is used to some extent for bread, to some extent in distilling, and can be used

with other grains for any kind of stock, but it does not appear on every farm, and where it is grown it is not generally for the grain but to fill a place in a rotation, such as furnishing green manure, fall or early spring pasture, or hay. It does well on rather poor soils and stands dry weather well, a quality which is resulting in its larger use. On account of its small leaf surface,

FIG. 47. PRAIRIE THRESHING.

it does not discharge moisture by transpiration as rapidly as oats. The straw, on account of its length, toughness, and even stem, is used in the manufacture of mats, hats, and baskets.

PEASE

The field pea can be grown wherever oats can be grown, and requires the same moist, cool climate. It seems to do best on soils plentifully supplied with lime. Like other leguminous crops, it requires inoculation to succeed well. At present the volume

of production of this crop is not large, but its importance is likely to increase, especially in areas where large quantities of forage and feed grains are grown for the support of increased live stock on the farms. It is useful in combination with oats for both green and dry forage, and the straw, if properly saved and not too ripe, is excellent roughage for sheep. It has a high value as grain feed for hogs when left to ripen and to be pastured on the field. It does not do well on wet or on very light land.

FLAX

Though grown principally for its fibre in old communities, as a prairie crop, flax is grown chiefly for its grain. It has about the same adaptation as wheat when it is grown for seed, but loose, sandy soils suit it best. It is frequently the first crop grown on prairie breaking. The seed is very rich in oil. One hundred pounds of seed will give between thirty and forty pounds of oil. The oil is used for paints and varnishes, and the remainder of the seed for stock food in the form of oil cake. For seed it is harvested like the ordinary grains, but when used for fibre is pulled by hand, bound into bundles, and threshed without injuring the straw. The part that is used for linen is the second bark. When grown for seed, about three pecks of seed are sown to the acre; when grown for its fibre, over twice this amount is used in order to secure long, fine stems.

EXERCISES

1. Examine a kernel of wheat for the recognition of the following parts: suture, cheek, kernel, and brush. 2. Collect samples of fall and spring wheats in small bottles properly labelled as such, and also as to variety and as to whether hard or soft. Compare them as to size, form, color, etc., by placing single grains side by side. 3. What varieties of wheat, oats, and barley are grown in your neighborhood? 4. Take a head of ripe wheat and pick the grains of wheat out of it section by section of the stem from above downwards, and arrange them in rows one above the other. Examine for the number of each, for fruit bearing and empty sections, and for variation in the size of grains. 5. Devise a plan of hand selection of seed. 6. Devise an experiment in boxes to show how stooling is caused. 7. Make an independent calculation based upon the number of seeds in a head, the number of stems in an observed stool, and the ascertained weight of a certain number of grains of wheat, as to how long it would take to produce a peck of wheat from a kernel or from the selected half of seeds in a head. 8. What are the various uses of the fanning mill? 9. Ascertain from the Dominion Statistical Year Book which province of Canada leads in the production of bushels of wheat, oats, barley, rye, pease, and flax. Also arrange the grains in order of the production of bushels in your own province.

CHAPTER XXII

FORAGE CROPS

Value of Forage. Forage crops are crops grown for the whole of their surface parts as bulky feed for farm animals. As there is on all lands quite a supply of natural vegetation that is useful for hay and pasture, the cultivation of forage crops has not gone on to the same extent as the cultivation of grains has. While native grasses are valuable for grazing and also furnish considerable hay in areas that are partly open and unsettled, it is generally more profitable to grow the cultivated forage crops on lands that have passed into private ownership than it is to leave them unbroken. Forage crops are just as important as grain crops. They do not exhaust the soil as rapidly as grain crops do, they make stock-raising possible, and make the returns from the farm more certain and varied.

Kinds of Forage. The crops included under forage all belong to two or three botanical families. The **graminae** include the cereals as well as what are commonly called the grasses; the **leguminosae** include alfalfa, pease, the vetches, and the clovers. The only other family represented is the **cruciferae**, an

example of which is rape. The different kinds of plants or crops go under a great many different names by those who grow them. **Hay** is the product from a group of plants used primarily for dry feeding, such as timothy and alfalfa. **Fodder** is a general term used to stand for long feed of any kind, cut and fed either green or dry. In some places fodder means only corn fodder, but we have broadened it to include feed from the small grain crops, such as oats, rye, pease, etc., as well as hay, and such other annuals as millet and vetch, and which in most cases may be fed either green or dry. In this class would come cured green oats, locally known as **green-feed.** When these crops are cut and fed green to stock they are commonly called **soiling crops,** which refers to the method of handling the crop in contrast to curing or pasturing. **Silage** is any crop that is grown and is cut green to be stored in silos. Corn is the most important and the most successful example, but other fodders are suitable for silage. **Pasture** crops are crops that are eaten where they grow. They may include hay or meadow grasses, the clovers, grains, or rape. This description refers to the way in which the crop is used.

Other kinds of crops that we should know the use of and that are grown from forage plants are catch crops, cover crops, nurse crops, and green manuring crops. **Catch crops** are crops that are

worked into a rotation between regular season crops, such as rape sown with oats for fall pasture, or rye for late fall or early spring pasture. **Cover crops** are crops that are grown to protect the soil, such as rye or rape. **Nurse crops** are grain crops with which grass seed is sown. **Green manure crops** are crops that are grown to be plowed under to add to the fertility of the soil or to improve the physical condition of the soil.

The Saving of Forage. The value of forage depends upon the time at which it is cut. It should be cut while all parts of the plant are still succulent, not after they have completed their growth. A plant to quite an extent produces its parts by stages in the order of leaf, stem, flower, and fruit. When the leaves and stem have about completed their growth they produce flowers and finally fruit, and by the time the fruit is developed the other parts are turning dry and hard and are not of much value for food. It is in young and growing plants that the food constituent, **protein,** which is the flesh-making substance in plants, is most plentiful. To secure the best condition in the whole plant we must cut it before it has stopped growing. Hay should be cut when it is just coming in bloom or has just come into bloom. Oats for fodder should be cut before the grain has passed the milk stage. It is sometimes recommended that market hay should be left a little

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Fig. 48. Harvesting Native Grasses.

longer than hay that is to be fed at home, but it should be clearly understood that forage crops are crops that are cut green if they are cut.

Groups of Forage Crops. It is not easy to classify forage crops on the basis of use, as the plants may be used in a number of different ways. It is possible, however, to make a grouping of plants because they are of the same general character. A useful classification is as follows:

1. Perennial meadow and pasture grasses: timothy, rye grass, brome grass, red top, and Kentucky and Canadian blue-grass.
2. Fodders: corn, small grain fodders, millet, vetch, and various mixtures of these.
3. Legumes: alfalfa, red clover, crimson clover, and alsike.
4. Rape.

MEADOW AND PASTURE GRASSES

Timothy is a standard hay crop. Owing to its value for working horses, the demand for it is constant and the prices of other kinds of hay are fixed in relation to it. The seed is cheap, it produces a good yield and the sod is easily got rid of. It generally produces well for two years, but after that it thickens so that the stem growth is short and light. It requires good soil and a liberal rainfall. In some parts of the West it suffers from the absence of early spring rains.

Western Rye Grass is a valuable hay rather than pasture plant. It is a bunch, rather than a creeping type of grass, that is indigenous to the whole of Canada and is very common in Western Canada. It is a deep rooting grass and does well in rather dry soil, but produces heavily under irrigation with proper drainage. It reaches its best production about the third year and is better hay for horses than for cattle.

Brome Grass has been introduced into Western Canada on account of its drouth-resisting qualities, though it does best in a rich, moist soil. It does not grow very fast the first year and should be sown without a nurse crop. It produces good crops of hay for a couple of years but it multiplies so rapidly through root spreading that it gets too thick to grow good hay and is then valuable chiefly for pasture. It is rather hard to eradicate and is regarded almost as a weed. It is generally got rid of by following it by a cultivated crop on deep plowing.

Kentucky Blue-Grass is valuable for permanent pasture. The grass is of fine quality. It does well on stiff or poor soil, but produces only a light crop of hay. It thickens by root creeping and so keeps itself renewed. Canadian blue-grass is of similar habit and quality. Red Top is used to a limited extent in permanent pasture mixtures. It produces a light hay crop on wet, sour lands, where it is

always found growing indigenously. These three varieties of grass are all good lawn grasses.

Grass Mixtures. In practice most hay and pasture grasses are sown in mixtures in order to secure a heavier yield, and also to keep land longer in grass and so save the expense of re-seeding and cultivation. Some grasses are shallow rooting and

FIG 49. MANITOBA FODDER CORN.

some deep rooting. Some do best in the first or first and second years, while others come on in the third year. Common mixtures are: timothy and rye grass; timothy, rye, and brome grass; and rye grass and Kentucky blue-grass.

FODDERS

Corn. Where corn can be grown best it produces large yields of grain which is valuable for the fattening of hogs and cattle. Dry corn st ks after

the grain is stripped off is called **stover**. In Western Canada our interest in corn so far is largely limited to its use as fodder. As fodder it has three uses: as silage, as a soiling crop, as dry fodder. The use of the silo is not yet general but is extending. By the selection of suitable varieties, up to twenty tons per acre of green fodder can be produced, which is more than can be grown of any other crop. It cleans the land and is a good preparation for wheat.

FIG. 50. THE SILO.

Small Grain Fodders. The most extensively used dry fodder crop grown in Western Canada is oats, commonly called green-feed. It is also an excellent silage crop. It produces a heavy yield, is palatable for all kinds of stock and is easily harvested. It is also sown with other grains, such as barley, but most commonly with oats, peas, or vetches. Combinations of these are extensively used as soiling crops as well as for pasture. Millet is used as a soiling crop. The grain crop of most varied use is rye. It is sown for fall pasture, is useful to keep soil from blowing in winter time, is grazed again in the spring for a while, and finally harvested for its grain, or it may be cut green for fodder and either fed green to stock or cured.

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Fig. 51. Sweet Clover. Putting a Poor Legume to a Good Use.

THE LEGUMES

The legumes, including alfalfa and the clovers, have always been highly valued on account of the large yields they give, the high quality of the fodder they provide, and on account of their value to the soil in a rotation. Most of the forage of Western Canada consists of the native grasses, tame grasses, and cereal fodders of similar form and habit. The distribution of the native pea and vetch and the success of scattered experiments indicate that the leguminous crops will become more common.

Alfalfa is a perennial plant lasting sometimes on the same land for thirty years. It is used almost exclusively for hay, and where it succeeds can be cut two or three times in a season. It is valuable for dairy cattle and sheep particularly, but is a good general food for stock of all kinds. As a pasture it is used chiefly for hogs, but cattle may be grazed on second growth alfalfa if accustomed to it gradually. It should be grown without a nurse crop, and requires careful preparation of the land. It does not reach its highest production until the third year. It is a deep feeding plant and requires a porous, well-drained soil and subsoil. Inoculation of the soil helps to secure a good stand if other conditions are favorable. It succeeds best on irrigated land. Where it succeeds well it becomes the

dominant crop in a rotation and gives a special character to the farm enterprise with which it is connected.

The Clovers. There are four varieties of clover that have been subject to trial: red, crimson, white, and alsike. **Red clover** is a biennial, though occasional plants persist for a year longer. It requires considerable moisture to succeed well. Though it is a deep rooting plant it will not stand periods of drought well. It thrives in a soil that contains considerable lime, that is fertile, and that is well drained. It is thought that the progress of tillage and drainage in areas of sufficient rainfall will make success with red clover common. It should succeed under irrigation, but the higher yield of alfalfa gives alfalfa first place. **Crimson clover** is an annual. It is not as good a hay plant as red clover, but is a good soiling plant and is used also for hog pasture. **White clover** is a plant of low habit that serves well in both hay and pasture seeding. **Alsike** is not a deep rooting plant like alfalfa. It has a root system near the surface and is not affected by poor drainage to the same extent that red clover is. It is a success in hay and pasture mixtures. In common with other legumes, the **sweet clovers** are useful in soil improvement, but are of little value for fodder on account of their woody stem and bitter taste. Pease and vetches have been dealt with under fodder, for which they are commonly grown.

RAPE

Rape is purely a pasture plant. It resembles the turnip in leaf growth, but its root is not fleshy, being more like that of the cabbage. Rape furnishes large supplies of succulent, tender feed. It is much relished by cattle, sheep, and hogs. It can be grazed early in summer, but is at its best with the coming of the first light frost. It requires well-prepared soil. It does well and gives heavy yields sown broadcast on new, rich soil, but is commonly a cultivated crop sown in drills in the older parts of Canada.

EXERCISES

1. What different kinds of forage are grown and used in your district? 2. Make a collection of half a dozen natural forage plants in your district. 3. What quality in blue-grass gives it its chief value? 4. How many tons of hay per acre are commonly secured from native prairie, timothy, and alfalfa? 5. What would probably be the effect of winter frost on deep-rooted plants on undrained soil? 6. Do you know any grasses that cure without being cut?

CHAPTER XXIII

ROOTS AND TUBERS

Uses of Roots. The growing of field roots is not general on the prairie. In areas of new, free, open land, and where labor is scarce and high, people are concerned with getting the most out of land with the least labor. Agriculture is extensive rather than intensive, and machine crops are preferred to hoed crops. Under other systems of agriculture, roots are considered a necessary part of a rotation. They require a good deal of cultivation, which results in putting the soil in good physical condition, and also in clearing it of weeds. They also are considered economical feed. Only about ten per cent of the root crop is actual food material or dry matter. The rest is water, but under good management fifteen tons to the acre are commonly harvested. In this country we do not regard root-growing as the most economical way of producing feed, but we recognize the value of roots when fed along with either dry, concentrated feed, or roughage. They appear to keep live stock in good health and help to digest the rough feed, or perhaps help live stock to make use of more of it. Roots

Fig. 52. An International Grand Champion from Manitoba.

are especially valuable for growing stock and for milk cows. Where corn is a successful crop, silage takes the place of roots for succulent feed in winter. It is probable that in most parts of Western Canada roots will be extensively grown in the future. The climate is admirably suited to roots.

Turnips. The turnip is the root that is most commonly grown for live stock. There are two general classes, called fall and winter turnips, with slightly different uses. The fall turnip is large, soft, and is white in flesh, and has light, green leaves and no stem. It does not keep through the winter and is fed early. The chief varieties are the White Globe and the Grey Stone. The winter turnip is commonly called the Swede, or ruta baga. It is smaller and firmer than the fall turnip, and is globular in shape and yellow in flesh. Its leaves are bluish green and it shows some stem. The two common varieties are the Purple Top and Bronze Top. It is highly flavored, and gives a rather objectionable flavor to milk unless fed in moderate quantities and after milking. Turnips are greatly relished by sheep, and have a limited use as feed for hogs.

Land intended for turnips requires careful preparation. It should be plowed deep in the fall and carefully worked in the spring. In places where much stock is grown the land is heavily manured in preparation for the turnip crop. Turnips should

be sown in drills two and a half feet apart, thinned to ten inches apart, and carefully worked with the cultivator and hoe.

Carrots of the field varieties are used chiefly for horses. They are not useful for working horses, as they keep them soft, but they help to keep idle horses in good health. They are deep-rooting plants, and require careful preparation of the land. The division of carrots into different varieties is largely a matter of type and shape, and not of difference in use.

Mangels. There are three varieties of roots belonging to the mangel group. These are the mangel-wurzel, popularly known as the mangel; the sugar mangel, which is a cross between the long, red mangel and the sugar beet; and the sugar beet. The first two are used for stock-feeding and the last for the production or manufacture of sugar. All of these are saccharine in content, which gives them their chief food value. Mangels are especially good feed for milk cows and for hogs, but are not specially good for sheep. They keep well, and are suited for late winter feeding. They are not as satisfactory a crop as turnips, as they are easily injured by early frosts.

Sugar Beets. The sugar beet is cultivated primarily for the sugar it produces. It contains nearly twice as much dry matter as turnips or mangels, consisting mainly of sugar. In Southern

Alberta it is a successful crop. The sugar beet requires intensive culture. It is the usual practice to summer-fallow land in preparation for the beet crop the year before the crop is sown. The seed is sown early, usually by the first of May, in drills about twenty inches apart. About ten or twelve pounds of seed per acre are required. When four leaves appear on the beets they should be thinned to about ten inches, subject to the strongest plants being saved. The ground should be kept well cultivated and free from weeds. The beets ripen about October. They are harvested by plowing with a regular beet plow, thrown in heaps and topped by hand. Yields run from twelve to twenty tons per acre, and the value is usually about five dollars per ton. The two varieties in common use are the Vilmorin and Klein Wanzleben.

The tops of the sugar beet plant are useful for fodder, and the pulp is excellent succulent feed along with grain and dry fodder for fattening sheep and cattle. The cultivation required for the production of a crop is a good preparation for wheat the following season.

TUBERS

The Potato is our only tuber crop. It is a field crop grown for table use. The potato is sometimes loosely included in root crops, because the part of it we use is produced below the ground, or because it requires the same kind of cultivation as the root

crops. The part of the potato that we use is not a root but a tuber. A tuber is an enlarged part of a plant. The potato does not grow on a root, but on an underground stem or stolon, as it is called. What we call eyes in the potato are buds. If we examine them we find that they are arranged spirally as the buds

FIG. 53. THE POTATO HARVEST.

are on the stem. The base or stem end of the potato has few buds, but the top, as it should be called, has quite a number. By a division of the potato we can produce generally as many potato plants as there are buds on the potato. Growing potatoes from buds is an artificial method of propagation. Frost destroys the potato easily. The potato contains from twelve to twenty per cent of starch.

Fig. 54*a*. Hampshire Ewes.

Fig. 54*b*. Shropshire Ewes.

Culture of the Potato. The potato requires loose, mellow, well-prepared soil. While it will produce well on most well-drained soils, it does best on a medium, light soil. This kind of soil works easily, and the potatoes grow well in it. It should have considerable humus, however, and it pays to manure liberally for a potato crop. Good crops are commonly grown in sod if the soil is of a good kind and the surface is thoroughly cultivated. It is not wise to plant the potato on the same land more than once without having other crops come between, as it is subject to disease and to attacks from insects which persist in the soil.

Stored potatoes sprout readily in the spring. In warm cellars, long, white sprouts appear, and the potato shrinks from loss of water and starch consumed in growth. These sprouts break off or are rubbed off, and the buds have to start all over again. If potatoes are spread in the light or sun on a floor they will sprout less readily, and the sprout will be small and hardy, and it is a gain in the season's growth. This is called **sun sprouting.** Sun sprouting is a kind of germination test. Sun-sprouted potato seed is usually cut one sprout to a piece; otherwise two. The seed pieces are commonly dropped twelve or fourteen inches apart in drills thirty-three to thirty-six inches apart. The market demands a medium-sized, smooth potato, not one in which the buds are deeply sunk, and this kind

should be selected for seed. The results of tests are unfavorable to the steady use of small potatoes for seed.

Potatoes require frequent cultivation. On dry lands potatoes should be seeded thin and cultivation should be frequent. Cultivation should be deep and close to the plants in the early part of the season, and should not be deep after the tubers have set. The soil should be worked from the centre each way to increase the volume of loose soil about the growing parts and to shield the tuber from sunburn. The hilling of potatoes is thought by some to increase the evaporating surface of the land, but experiments have not shown that flat cultivation produces better crops than working the mold into drills. Where potatoes are grown on a large scale, machinery is used for both dropping and digging.

EXERCISES

1. Give as many reasons as you can why roots should be grown. 2. Discuss the wisdom of the statement: roots are ninety per cent water, but it is mighty good water. 3. What objection would you make to a ration for live-stock of all grain, all fodder, all roots? 4. Explain how the putting of manure on a root crop helps a subsequent crop of wheat or barley. 5. Is either of the two common kinds of field turnips suitable for table use? 6. Compare wheat, turnips, and sugar beets in relation to soil improvement and wealth production. 7. Make a drawing showing all the parts of a potato plant, and give other examples of stolons.

CHAPTER XXIV

TREES

From Sod to Soil Surface. The area included in the Prairie Provinces is not all prairie. Part of it is prairie, part of it is park land, and part of it is timber land. While the prairie aspect seems to be characteristic and constant, it is not thought that the prairie was always without trees. If an area were carefully fire-guarded and enclosed so as to prevent close grazing, it would undoubtedly develop tree growth, though the process might appear slow to us. If the grass were undisturbed it would grow a top of vegetation that in its decay would create soil conditions that would be favorable to scrub growth, which would be followed by still higher growth with the accumulation of loose mold and shelter from sun and wind. This is nature's method of making the earth progressively fertile and attractive. It is known that the Indians were in the habit of setting out fires to improve the buffalo pasture by providing fresh springing grass, and it is generally thought that, whether in accident or design, fire has been chiefly responsible for stripping the prairie of all vegetation except

the grasses, though climatic differences would account for differences in the volume of tree growth in the first place.

The prairie stretches are sometimes referred to as the Grass Lands of the Great Central Plain. These lands are characteristically suited to the production of the cereals which are also of the grass family. Owing to the ease with which these lands can be converted to production they have been rapidly settled. They simply have to be turned with the plow. Sometimes it is done with the patient cattle working in the natural day and tearing up a single ribbon of sod at a time, or it may be the work of the great engine working both by day and by night, and turning acres instead of inches at a round.

The soil is very productive. The mineral ingredients have been well fined and mixed by glacial action, and the land is overlaid with a rich humous covering with which a humble vegetation has been dressing the rock waste year by year. In some places this rich top soil has been gathered by the streams and deposited in the bottoms of lakes that have long since disappeared. The result is that the conversion of the prairie from a sod to a soil surface has been very rapid. It is sometimes said that the bountiful production of the prairie with little expenditure of labor encourages money-making rather than home-making.

Fig. 55*a*. Primitive Power.

Fig. 55*b*. Modern Power.

Conservation. The turning up of the prairie has given rise to insistent problems of conservation. We have learned in our crop studies that it is necessary to conserve soil fertility by returning crop waste and manure to the soil, by green manuring, by crop rotation, and by including as often as possible in a rotation, leguminous plants where they will grow. Tree planting is an attractive and important work with a distinct aspect of conservation. In its larger features it has become a concern of governments, and has for its central purpose the providing of a timber supply for future use. The business of developing and caring for timber is called forestry. The work done by the Dominion Government concerns itself with the re-seeding of stripped areas; the seeding of new areas unsuited to agricultural use; the establishment and extension of timber reserves, and also with the fire-guarding of forests and the regulation of brush disposal.

It is recognized also that forest conservation has other important results besides saving and increasing the supply of timber. In the first place, forests create by the materials they furnish, such as leaves and twigs, and by the shade as well as protection against blowing which they furnish, a deep accumulation of black mold. The black soil of the forest retains moisture well, and the trees shade it from surface evaporation. This makes the discharge of water to the valleys steady and regular.

If the sides of the valleys are stripped of trees, the humous material not only ceases to accumulate, but it disappears by both washing and blowing. Valleys that are denuded of forests are soon denuded of black soil. Channels are cut deep by erosion. Flooding and soil washing are common on the lands at lower levels. While the timber supply is the chief concern of forestry, the incidental benefits of forest planting are of great economic importance.

Tree-Planting on the Prairies. Tree-planting on the prairies is usually undertaken more for its incidental benefits than for the supply of timber which it may furnish. The natural conditions are not favorable to the establishment of forestry enterprises. Owing to the extreme climate, light rainfall, and short growing season, tree growth is slow. The rapid evaporation caused by the high winds means low growth. The stately trees that we see in forests have germinated in a loose, moist soil in the first place. As seedlings, and also as saplings, they have had favorable soil conditions, and have been shaded by the vast trees amidst which they have sprung and by each other. They have really become great trees themselves of fine girth and stature before they have lost the parental shelter. These tall trees of even girth are real timber trees. We cannot grow many varieties of trees on the prairie, the varieties we can grow are

not the most valuable timber trees, and we cannot grow them in very great perfection for timber purposes. The growing of trees on the prairie is only an adjunct to farming, but the economic benefits from it are sufficiently important to make the planting of trees worth while.

FIG. 56. WINDBREAK OF COTTONWOOD.

Benefits from Tree-Planting. The word most commonly used to describe the tree group on the prairie is the word windbreak, which shows how trees are chiefly regarded. The windbreak is valuable:

1. To check the blowing of the soil. The fine soil of the prairies when dry is easily carried away by the wind, and, of course, the surface soil is the most valuable. It is the humous materials which are lightest also. Blowing affects the soil of summer-

fallows, young crop, and even crop of considerable height. Sometimes young crop may be blown right out of the ground in either winter or summer. It was observed at the Indian Head Experimental Farm that a fifteen-foot-high windbreak completely protected a grain crop from injury to a distance of seven hundred and fifty feet, or for fifty feet for every foot of height in the windbreak. It would probably lessen the injury to the crop or soil surface for a considerably greater distance.

2. To check snow blowing. It is not uncommon to see the total snowfall in certain parts of the prairie entirely carried away from the surface of fields. The snow lifts soil with it, and the loss is a double loss of moisture and fertility. The catching of snow by a windbreak itself insures the better establishment of the windbreak by the accession of leaves, stubble, black soil, and moisture.

3. To check evaporation on the lee side of the trees. Observations have shown that the evaporation during a high wind is much greater away from a windbreak than it is near it. Windbreaks are absolutely necessary for orchard trees on the prairies, and their benefit for the protection of the loose soils and the plants of gardens against drying is obvious.

4. To shelter stock. Comfortable buildings are expensive on the prairie, and certain kinds of stock will grow and keep in good condition running out-

side if they have food and shelter. The benefits of fresh air and exercise compensate for the absence of warmth. Shelter saves feed and makes growth possible.

5. To shelter farm homes and other buildings. It is much more comfortable, both within and about farm buildings, if they are situated in shelter, than it is if they are on wind-swept ground.

FIG. 57. THIS KIND OF STOCK COMMONLY WINTERS OUTSIDE.

6. To add to the beauty and value of farm property. The attractiveness of surroundings adds much to the enjoyment of home life. Too many homes on the prairies have been left unimproved as to their surroundings. The actual selling value of a place is increased by the planting of trees around the buildings, along the lanes, and along permanent fences.

7. To furnish a supply of wood and of pole timber. The development of tree-planting has already resulted in some parts of the prairie in furnishing domestic wood, pole timber for building, and posts for fencing. This is not an immediate benefit from tree-planting. It comes with the

development of fairly large plantations and after they have made a stand that establishes something like forest conditions, such as, the holding of their own leaf mold and other waste, the retention of moisture by reason of the mold and shade together, and the rapid production of natural seedlings. Wood or light timber may be supplied from windbreaks by cutting out grown trees of temporary varieties, in order to make room for more permanent sorts that are coming into good growth.

The Planting and Cultivation of Trees. In the absence of the usual conditions under which trees or forests are commonly produced, the farmer must look on trees as a crop until they are well established. This means that the soil must be carefully prepared and the trees cultivated for two or three years. It will pay to give a season to the preparation of the soil. If the trees are to be planted on land that has already been cropped, it should be carefully summer-fallowed to secure a store of moisture. If they are planted on new land it should be plowed three times. The first plowing should be quite shallow and should be done early in the spring. It should be disked a couple of times to pack it down and fill the seams so as to hasten decomposition. It should then be backset two or three inches deeper, well surface-worked, and plowed a third time still deeper late in the fall, harrowed, and left until spring. It will not require

working in the spring before planting. The plow may be used to make a furrow in which to set the trees. Intertillage is by the horse and scuffler.

Windbreaks should be set for protection against the west and north winds chiefly. Most of the fast drying summer winds are from the south-west. Protection on the south side helps to check evaporation from these winds, but a south bank of trees should not be set up close to small plots to be protected, as it shuts out the sun. Trees do not need to be set close to buildings in order to give protection. If they are set close they bring the snowbanks too close to the buildings. Trees for windbreaks should be set in rows four feet apart, and the trees should be about the same distance apart in the row.

A plantation should contain a number of varieties. Some trees quickly shade the ground and help to produce a good soil cover. The Manitoba maple is of this sort. It produces an abundant leaf growth, but does not last for many years. The poplars are most used in the Western Provinces on account of their rapid growth and hardiness. The ash, elm, and evergreens are slower growers, but make the best trees ultimately for shelter or decoration. If ash, elm, and evergreens are intended to make the ultimate shelter belt they should be planted so as to make a good group after the temporary trees have run out or have been cut out.

Maples and cottonwoods may be set on the outsides of the plantation, and such trees as evergreens, elm, and ash, set eight feet apart on the inside with intermediate rows of Manitoba maple, making four foot spaces for cultivation between each pair of rows.

Trees should be planted firmly, and a little deeper than they grew before transplanting. They do not need manure. Surface-working should be directed by the condition of the surface soil, as in general dry farming practice. It should be frequent early in the season, but should cease about the month of August. New wood grown after this time is apt to be set back and killed by early frosts. The poplars and so-called cottonwoods can be grown from cuttings. The bulletins of the Forestry Branch of the Department of the Interior furnish valuable information on care and varieties.

Native and neighboring varieties of trees should be the first ones selected for shelter and general group planting. These under reasonable care will turn out ninety per cent good. Others should be chosen on account of such similar climatic adaptations as will give reasonable hope of success. In the case of all trees, whether grown from cuttings or seed, considerable time is saved by procuring well set nursery stock, but it is particularly important to secure stock from home nurseries to lessen the losses from long shipments, but more particularly to get trees that are grown under conditions similar

Fig. 58 The Clydesdale.

Fig. 59. The Percheron.

to those into which they are being transplanted. Local nurseries can easily furnish co-operative assistance to tree-growing enterprises, and have a direct interest in having their stock give satisfaction.

It is important to feel in the first place that the planting of the tree is a beneficent act, and in the second place, that any tree is beautiful in right environment. A native choke-cherry or saskatoon, or a group of these, may be just what a particular corner requires.

EXERCISES

1. What different kinds of injury or inconvenience are caused by wind in your district? 2. Are there any natural plant societies which include trees in your neighborhood? If so, what is their environment in contrast to that of places without trees? 3. Visit these groups to ascertain what different kinds of trees and shrubs are included in the plant societies. How are they arranged, and of what use are they to each other? 4. From what kind of environment or situation would you choose a tree for single planting? 5. Are there any places about your home that would be improved by trees for either shelter or decoration? 6. Choose and carry out an experiment suited to your circumstances from the following: (*a*) The growing of plants from the seed of the Manitoba maple, cottonwood, ash, or elm. (*b*) The growing of trees from cuttings of cottonwood or willow. (*c*) The growing of trees from both suckers and cuttings of Russian poplar. (*d*) The transplanting of one native coniferous tree and one deciduous tree from your neighborhood. (*e*) The planting of two native shrubs from your neighborhood. (*f*) The securing and planting of caragana seedlings for a short hedge, or of Virginia creeper. Make the cultural conditions as good as you can by learning from books, from the experience of others, and by your own judgment and observation.

CHAPTER XXV

GARDENS AND GROUNDS

Use of the Garden.—The fields of the farm commonly provide a number of crops that are suitable for table food. The potato is commonly grown under field conditions for economy in working, and is usually a farm crop for market as well as a home supply crop. Onions are generally grown as a field crop for market as well as for domestic use. Corn is ordinarily a field crop, where it can be grown, and the pumpkin and squash are generally grown in the field on account of the room that they require. For this reason they are commonly limited to the farm and are not included in garden crops for town cultivation at all. The garden, however, should be looked upon as a necessity for both the town and country home on account of the variety and succession of vegetable foods it furnishes for both summer and winter use.

In town we commonly speak of the garden as a kitchen garden. It is usually situated at the back of the house, while in the country we frequently find the garden plot and such decoration as lawn, trees, and shrubs in close association. Frequently the tree

Fig. 60. Foliage and Flowers Change a House into a Home.

growth answers for shelter as well as decoration, and the garden is helped in this way. A well-tilled garden plot does not necessarily take away from the attractiveness of the setting for the farm home if the parts are suitably arranged.

In many western towns there are many vacant lots that may easily be converted to gardens for those who have not sufficient ground about their own homes. Their cultivation vastly improves the appearance of the street and may yield a profit to enterprising boys and girls.

Garden Soils.—Garden soils are to a considerable degree made soils. A very light, sandy soil may be improved by the addition of manure, or a clay soil opened up by careful tillage and the use of manure combined. The best natural soil is a loam or sandy loam that is liberally supplied with humus and that is well drained. A soil of this kind is easily worked. Different plants have different soil adaptations. Such vegetables as carrots and radishes do not grow well on clay soils, but on sandy soils they grow rapidly and are clean. Cabbage and cauliflower do well on heavier soils. Onions and celery do best on reclaimed, black lands. Gravel is a poor soil for gardens.

Exposure.—The aspect or exposure of a garden plot, or of different parts of it, is important in relation to crops. Land with a southern or southeastern exposure will produce earlier crops than one

with a northern exposure. On the other hand, trees and bush fruits may suffer by being started too early. Special parts of a garden are sometimes better than others with respect to warmth of soil, slope, elevation, or shelter, or from the reflection of heat from fences or buildings. Conditions of this

FIG. 61.—CORN AND TOMATOES PROFIT BY FAVORABLE EXPOSURE.

kind are important in relation to plants such as corn, the tomato, and the gourds that reach their perfection in a warmer climate.

Preparing Garden Soil. — The preparation of a garden plot for spring planting should be done in the previous fall. The land should be plowed or dug deep, and in dry areas should be harrowed. Where land requires manure it should be applied

the year previous to that in which the soil is planted so as to become thoroughly a part of the soil. In areas where dry farming is practised the garden should always be on summer-fallow, that is, it is necessary to cultivate twice as much land as is cropped. The use of manure on dry land the same year as it is cropped is wholly inadvisable, as it opens the soil to air and hastens the loss of moisture by evaporation. When used on summer-fallow, however, it improves the soil for moisture-keeping later. The soil should be made thoroughly fine in the spring. This warms it, increases its capacity for moisture, and so hastens germination and improves the conditions for growth.

The Hotbed. The hotbed is a most profitable adjunct to the garden in both town and country. It is a device to make heat and keep it, and still admit sunlight as it does through the sash covering. A good start and rapid growth are necessary for both quantity and quality in vegetables. The hotbed has two uses. It can furnish a supply worth while of such early vegetables as lettuce, radish, and onions, and can give a month's rapid growth before good conditions of growth are established outside, for such plants as cabbage, cauliflower, tomatoes, squash, vegetable marrow, and celery. The hotbed should be planted about the first of April in order to have plants ready for setting out by the first of May, though the date may vary according to the

condition in different localities, or to the taste and convenience of the gardener.

The hotbed is simple in construction. In some places it is sunk below the level of the surface of the ground, but this is not necessary. The conditions which make a hotbed desirable may be secured without this trouble. It should be located in a warm, sunny place. The south side of a fence or

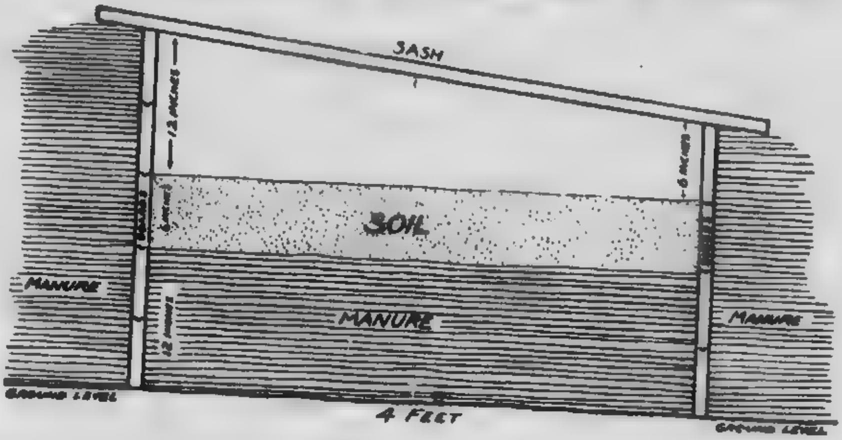


FIG. 62. END VIEW OF SMALL HOTBED.

building is a desirable situation. A convenient size for a small hotbed is four feet from front to back and six feet long, with the front two feet high and the back two and a half feet high. This will allow for a foot or more of manure, from four to six inches of soil, and will leave six inches of open height at the front, and twelve inches at the back for the plants. The manure should be fresh horse manure mixed with litter. It should be fermented in heaps before being put into the hotbed. It should

be well trampled in, and should be put in in such quantity as to be of the required depth after it has settled by further fermentation. It will probably take not less than a week to lower in temperature sufficiently to be safe for planting. It may be tested with a thermometer. It will probably go up to 120 degrees, but should not be planted until it has gone back to 90 or 95. When it is right, put in about five or six inches of sandy, black loam. It should be banked on the outside with manure.

A cold-frame is sometimes used to hold plants between the time they have been well started in the hotbed and their final setting out. It is similar to a hotbed but without the manure, and is intended to harden the plants, but similar results can be secured by leaving the sash of the hotbed open. This permits the reduction of heat and the entrance of air from outside.

Common Garden Crops. The word vegetable is not a name with scientific meaning or limitation, as the word legume or even root is, as applied to crops. It is a general word used to designate most of the things grown in the garden for table use, except sweet fruits. It includes plants belonging to a variety of families and of which any or all of the parts may be used, such as the pod of the bean, the root of the carrot, the flower stem of cauliflower, the leaf stalk of rhubarb, etc.

The minute culture of garden plants is set out in special works on horticulture. For practical purposes the directions on seed packages are generally sufficient, and they are clear and concise. For the sake of order and economy in working, most gardeners now plant their crops in long rows rather than in beds. Where the garden is large, as it may be in the country, a horse cultivator may be used for intertillage. The rows should run north and south so that one class of plants will not shade another. For this kind of cultivation a long narrow garden is better than a square one, as it saves short turns.

Fig. 63. Celery.

A garden usually includes a number of crop groups besides individual plants. Beets, carrots, parsnips, and radishes are root crops. The seeding for beets and carrots should take account of both summer and winter sorts. Radishes should be sown every week or ten days so as to furnish a succession, but the quality is better early in the season than it is late. Part of the parsnip crop is commonly left in the ground over winter. Parsnips are improved in both flavor and texture by the soil

Fig. 64. Representative Dairy Breeds.

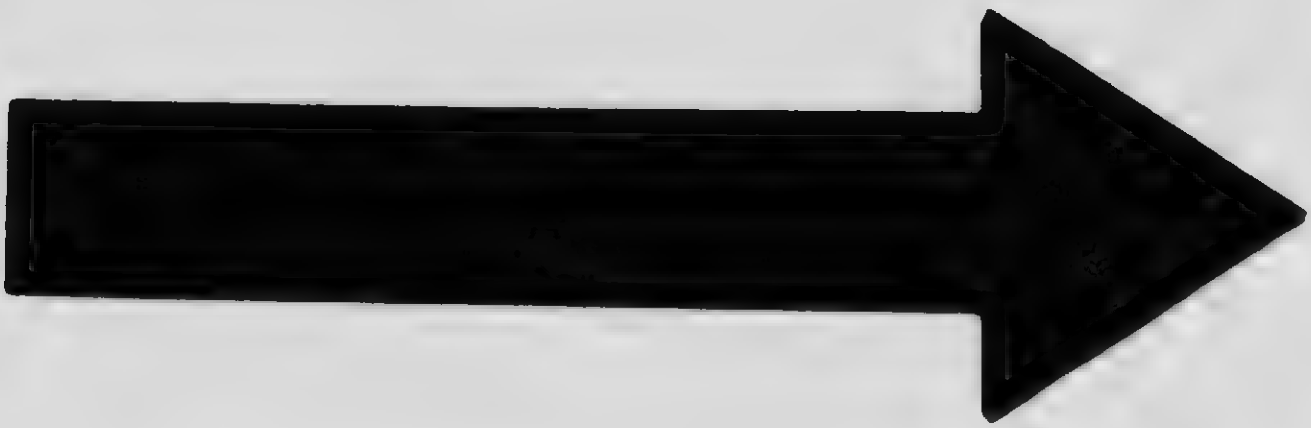
and frost, but should be lifted before they start to grow in the spring.

Garden peas and beans are used in a similar way except that the whole pod is cooked in the case of the bean. Dwarf varieties are most popular in both. Beans are easily injured by late frosts and cannot be sown as early as peas. Where shell beans, as they are called, are grown they are usually a field crop.

Cabbage, cauliflower, and Brussels sprouts are of similar habit and use. They require considerable moisture. Cauliflower is uncertain where moisture is intermittent. Early and late varieties of cabbage should be planted.

Of pot-herbs or greens the most common are Swiss chard, spinach, and young beets. The chard has a delicate and enticing flavor resembling celery. The thinning of the beet rows can be regulated so as to furnish greens for the table. Salad plants are plants that are used for dressing and food combined. Of these, lettuce, cress, and parsley are most common. A succession of lettuce should be provided by sowing every week.

The gourd plants, sometimes described as fruits that are not sweet, include the pumpkin, squash, marrow, cucumber, and melon. The first three are successful in Western Canada, while melons do not succeed, and cucumbers succeed or fail according to the season. A good crop can be secured by



MICROCOPY RESOLUTION TEST CHART

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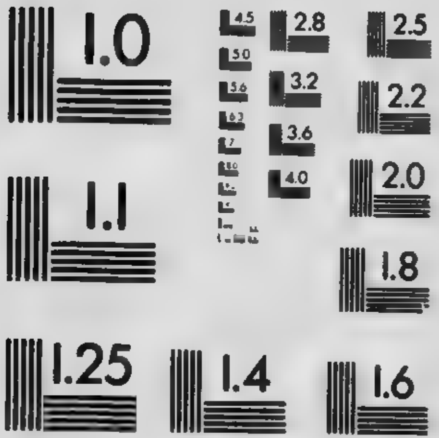

planting them rather late in the hotbed and letting them produce there.

The onion crop is the most important market garden crop grown. There are a number of ways of growing onions. They may be grown from seed, the onions that are thinned out being used green

FIG. 65. NORTHERN APPLES.

while the others are left to mature; green onions may be grown from sets planted in the spring, and very early spring onions can be produced from such varieties as the Egyptian, which are planted as sets in the fall and produce a good crop of young onions in the spring.

Among individual plants, tomatoes do well in Western Canada under proper treatment. The

plants require a warm, sunny exposure, they should be planted not less than four feet apart, staked, and should be well cut back as to tops and side leaves after the fruit has formed. The crispness and flavor of Canadian celery is an outstanding example of the effect of suitable soil and climate on all our vegetable plants. It is considered a very wholesome plant. Squaw corn may be made to produce a supply of cobs for table use. Other varieties will come into use by selection and careful cultivation. Rhubarb is a garden staple. It should be set in the fall from root divisions containing two buds each. It should be protected during winter by a covering of short manure which should be worked into the soil in the spring.

Garden Fruits. The fruits grown on the prairie are chiefly limited to the strawberry, raspberry, black, red, and white currants, and gooseberries. Among tree fruits crabs do satisfactorily, and varieties of plums, cherries, and apples only require the development of species suited to the climate.

Beautifying Home and School Grounds. The garden has been considered in order to indicate what can be done with the soil about the farm or town home. Most homes have a garden, but they also have a door-yard which may be improved or unimproved, and the attractiveness and value of the home increased or lessened in consequence. The common decorations of house surroundings consist

of trees, shrubs, flowers, and grass stretches or lawns. There are two general types or plans of decoration. One is the conventional, which runs into straight lines and geometrical figures; the other is the natural type, in which the evidence of design is as slight as possible. The conventional type helps to emphasize the order and neatness of well-kept grounds. The natural type is displacing the other. The natural type is well suited to large grounds.

The house is the centre from which landscape gardening should begin. A low style of house is best suited to the prairie. The high, narrow house is a false note in the landscape. Trees may help to improve the appearance of the house by filling the deep angles made by the vertical lines of the house and the ground line. The house should have a rather unobstructed view in the front. Trees belong to the side rather than the front of the grounds. The immediate front of the house should be lawn. A lawn is beautiful on its own account and should be an unbroken stretch of grass and should not be dotted with trees and shrubs or cut up with flower beds. The trees and shrubs should be set back from the lawn. Exception may be m in the case of natural trees of striking individi...l beauty or of groups of trees. Walks should not run in straight lines but in easy curves. Shrubs or flower beds may fill corners and angles in the

FIG. 66. REPRESENTATIVE BEEF BREEDS.

grounds around the house. Vines may soften the angles of buildings or shade a veranda. Flowers of humble growth may border paths or walks. Sweet peas may cover a trellis division between front and back yards. Trees should vary between deciduous and evergreen and should be in groups in most places, though rows of trees dress up fence divisions or lanes. Hedges serve the same purpose. Evergreens should be placed for winter shelter. All grounds should have tree corners. A single evergreen has rather a solitary aspect. Evergreens should not be trimmed into fantastic shapes or trimmed of their lower limbs. Trees of low habit are to be preferred to others for the prairie.

FIG. 67. VINES MAY SHADE A VERANDA.

Grounds should not be fully made and completed in a season. The plan should take some general form in the liking and imagination of the home-maker and may not, for example, have either a blue spruce or cut leaf birch the first year. Wild cucum-

ber and hops may dress or shade one part of the veranda while the Virginia creeper grows in another. Each year should add something to improve a bald place or to satisfy the desire for a new tree or flower or shrub. The growing of trees is not likely to be overdone on the prairies. Boys and girls should make home gardens for profit and experiment and should plant trees of their own which will grow in beauty and use and strength as boys and girls do themselves.

FIG. 68. HYACINTH.

Boys and girls should combine and share on the school grounds the pleasure they get from improving work. They should work together for enlarged school grounds, so that they can grow flowers, trees, and shrubs, and experiment with soils and plants, besides having room to play. They should dress their school fences with trees

and the corners with clumps of trees, or improve the entrance to the school in the same way. They should cut or pull the weeds and mow the grass before it gets sere. They should make flower plots and borders together and contribute plants, cuttings, or seeds for the common pleasure.

EXERCISES

1. What do you understand by a made soil? 2. How would you explain the difference between field and garden tillage? 3. Secure the privilege of cropping a piece of garden, not less than eight by twenty feet, to grow not less than six kinds of garden vegetables, not less than three kinds of flowers, and to conduct one culture experiment connected with seeds, tilling, watering, or manuring. Draw a plan of your plot before you begin work. 4. What trees are native to your district? Which do you prefer? Do you intend to plant one or more trees this year? If so, what precautions do you intend to take in moving them? 5. What flower can you contribute to the decoration of your schoolroom? 6. How may hyacinths be grown? How do they multiply? 7. Choose at least two flowers from the following list that you intend to plant and take care of this year: sweet pea, aster, pansy, verbena, zinnia, larkspur, phlox, nasturtium, pink, and single poppy.

CHAPTER XXVI

PLANT ENEMIES

Plant Enemies.—A plant enemy is anything that operates against the success of a crop with respect to either quantity or quality. The chief enemies of crops are weeds, insects, and fungi.

Climate and Cropping in Relation to Weeds.—A weed is commonly defined as a plant out of place. There are two important conditions or causes that favor weed growth in Western Canada. These are the climate and the system of cropping. The precipitation of the open part of the year comes almost wholly in the growing season. Plants good and bad are rushed to maturity by a fertile soil, considerable rainfall, and also warmth. The harvesting season is rather sharply defined by the cessation of rainfall, and plants of all kinds ripen promptly. The grain is cut and threshed, and with it some of weeds. Others have shed their seeds or have had them rattled out in the stubble. They fall on dry soil and do not germinate, and so are not destroyed as plants by the frost or the disk. The seeds may be covered up by cultivation, but they lie unharmed over winter. Many of them, like buckwheat and

FIG. 69. TYPES OF SWINE. *Bacon*—1, BERKSHIRE; 2, TAMWORTH. *Lard*—3, DUROC JERSEY; 4, POLAND-CHINA.

mustard, have thick, oily skins; volunteer crops of grain are from shelled grain that has survived the winter in or on top of dry soil. In the same way the weed seeds also are ready for the next season. Some of our worst weeds are winter annuals, and if they do start in the fall, they are not killed, but go on growing in the spring. Another feature of our climate helps to increase weeds by distributing them. This is the high winds.

The system of cropping on the prairie is favorable to the increase of weeds. We do not have diversified rotations. Sometimes we have two wheat crops in succession, and if we do not have wheat following wheat, we commonly have oats or barley, which are crops like wheat, seeded about the same time, so that the weeds have a chance to grow and ripen with the grain year after year. If we had a diversified rotation, in which cultivated crops or early cut forage crops were grown, the weeds would not have a chance to ripen as they have in a grain rotation.

Distribution of Weeds.—There are certain ways in which weed seeds are distributed. A common way is in manure. Wind and water carry seeds for long distances. Some seeds cling to the garments of men and to the coats of animals, and finally are rubbed off. Weed seeds are carried from one farm to another, or from one field to another, by machinery. Weeds are sometimes brought in by impure

FIG. 70.—COMMON WEEDS:—SHEPHERD'S PURSE, HARE'S EAR MUSTARD, AND COUCH GRASS.

seed from distant places. Seed is not always well cleaned at home. Weed seeds come in hay or in cars, which carry impure seed. The screenings from the elevators are sometimes moved away in open wagons, for sheep feeding, though this is generally forbidden.

Fig. 71.—The Loco Weed.

Where weeds are very troublesome, governments pass legislation which is intended to prevent weeds or destroy them. Certain classes of weeds are defined as noxious on account of the injury they work to crops, penalties are imposed, and inspectors appointed to enforce the laws. The Acts of the various provinces should be consulted to find out what weeds are defined as noxious. The provinces all issue bulletins on weed extermination. Collections of the noxious weeds should be made so that they will become familiar.

Injury Caused by Weeds.—The effects of weeds are as follows:

They rob the crop of moisture, food, and sunlight.

They lower the value of grain by making it a poor sample, and by the impurity of the weed seeds.

They involve labor and expense in combatting them.

Some weeds are injurious or even fatal to live-stock, as loco, water hemlock, wild onion, and larkspur.

They destroy the fleeces of sheep or reduce their value.

They spoil the appearance and lower the value of farm lands.

Destruction of Weeds.—Annual weeds must be got rid of in the season in which they appear. If land is not too dry in the fall, disking will cause seeds to germinate, in which case they may be destroyed by the frost or turned under by the plow. Land should be worked early in the spring to cause them to germinate. They are then easily destroyed by harrowing before the crop is sown. Harrowing land after the crop is set also helps to destroy them. If they are not too numerous, they may be pulled by hand as they appear in the crop.

Biennials are plants that produce seed in the second year. They should be cut down when in bloom. If cut too early the root may contain sufficient food to mature flowers and seeds the second

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Fig. 72. The Cotswold. A Long-Wooled Breed.

Fig. 73. The Oxford. A Middle-Wooled Breed.

time. Spudding below the crown is the most effective way of cutting them. A very heavy forage crop, or a well-cultivated crop on deep plowing, may destroy them, but the most effective way is to summer-fallow. The land should be kept bare and cultivated with implements that tear out the roots and bring them to the surface, where they may be gathered with the drag-harrow and burned when dry. The disk is not useful for this work. Where weeds of any kind have got a start on a summer-fallow, sheep will usually eat them off if held on the land in sufficient numbers. They also pack and fertilize the soil. The sowing of rape and of grain fodders is sometimes resorted to in order to choke weeds and graze them off. Early cut green feed on well-tilled land does away with weeds. It has been demonstrated that mustard may be destroyed by spraying with blue vitriol or with copperas, without injury to the crop.

Precautionary measures take account of securing clean seed by hand selection or the use of the fanning mill, the burning of screenings, or the feeding of them exclusively to sheep, and the keeping of machinery clean.

INSECTS

Conditions Favoring Insects. Insects, as well as diseases, are more common in old lands than in new lands. Once they are established they tend to

persist and to increase. The vigor of crops on new land helps them to resist attack, while soil exhaustion, neglect, poor tillage, and weak crops have the opposite effect. Where crops are weak from scarcity of moisture they seem to be more subject to attack than where moisture is plentiful. Western Canada has not been greatly troubled with insects, but is not entirely free from them.

What an Insect is. The term insect is an exact term and does not include all small or minute animals. Spiders and worms are not insects. An insect has six legs, three body divisions—head, thorax, and abdomen—and may have either one pair or two pairs of wings. Examples of insects are butterflies, grasshoppers, potato and other beetles, flies, mosquitoes, and bees. The grasshopper is the best example from which to study the parts. Most insects, though not all of them, pass through four stages of growth or **metamorphosis**, as it is called: the **egg, larva, pupa,** and **imago** stages. The terms egg, grub, cocoon, and adult may be more familiar. It is in the grub stage that insects do most damage, as in the case of the cabbage worm and potato slug.

Classes of Insects. For the discussion of ways of getting rid of them, insects are divided into two classes: biting insects and sucking insects. Biting insects are those that eat the parts of a plant; sucking insects are those that bore into a plant and

live on its sap. Biting insects are destroyed by putting poison on the parts that they eat; sucking insects cannot be reached in this way and are killed by emulsions that corrode their bodies or choke their breathing by smearing. The most common poison employed is Paris green applied as a spray, using one pound of Paris green to fifty gallons of water. A common emulsion consists of half a pound of laundry soap dissolved in a gallon of hot water mixed with two gallons of kerosene and diluted with twenty gallons of water. It is used also as a spray.

Grasshoppers are sometimes destructive. They are found in small numbers every season. In an ordinary season the birds keep them in check. When they do come in large numbers their coming appears as a disastrous visitation and nothing can check them. They move from the mountains out on to the plains and eat everything that is green. Their appearance in great hosts cannot be foreseen or explained. They disappear as suddenly as they come. The young that are bred out in the plains in a crusade do not seem to be able to survive.

Potato Beetles. Potato beetles have not yet appeared in great numbers, but they should be destroyed wherever they appear. One beetle will lay from five hundred to a thousand eggs in a season. They can be successfully got rid of with Paris green.

Cabbage Moths. The same treatment destroys cabbage or tomato grubs as is used for potato beetles, but poisons should not be applied to plants that are ready to be eaten.

Plant Lice and Scale Insects, such as appear on cabbage plants and in some places on trees, are destroyed by emulsions.

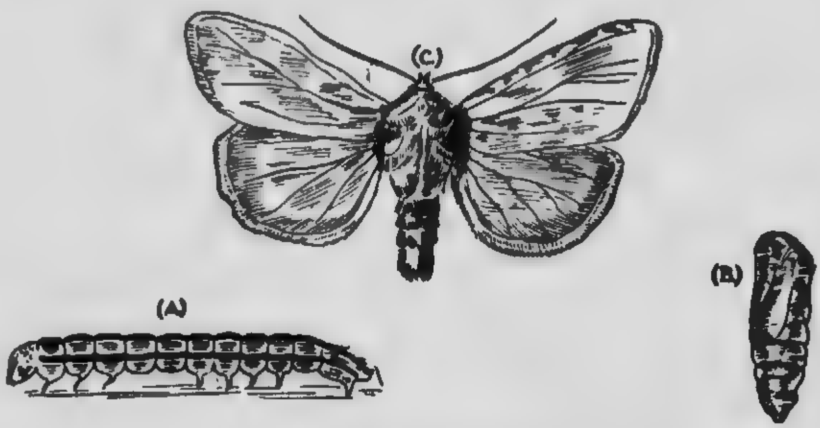

FIG. 74. THE CUTWORM. *a*, LARVA STAGE; *b*, PUPA STAGE; *c*, ADULT STAGE.

Cutworms. These insects attack both farm and garden plants and are, perhaps, the most destructive insect pests on the prairie. They are bad in dry climates and in dry years, and usually on spring plowing of sod. The cutworm is a dark, grey worm, faintly striped, and has a soft body. The adult form is a moth. It lays its eggs on grass stems in the summer. When the eggs hatch the larvae fall and burrow down into the soil, where they continue to grow until the frost of winter. In

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FIG. 75. TYPES OF CHICKENS. EGG, GENERAL PURPOSE, AND MEAT BREEDS.

spring they eat everything within reach, cutting off the plants just above the surface of the ground. The best way to reduce their numbers is by poisoned bait, such as bran saturated with Paris green. This may be used before the crop is sown by putting it in small heaps on the surface where land is known to be infested. After the plants are up the bait should be placed beside the plant. This applies to small garden areas.

Where large areas of farm lands have become infested, the worms may be destroyed in large numbers in trap furrows, as they are great travellers. To keep them out of a field, or to destroy them while moving from field to field, plow a steep furrow, which should be smooth on the sides and not broken or rough. Sprinkle shorts poisoned with Paris green at the rate of ten pounds for sixty rods, or strew green weeds or green alfalfa in the furrow after dipping the green stuff in a mixture of twelve gallons of water, one gallon of molasses, and one pound of Paris green. Late fall plowing helps to destroy the larvae.

Pea Weevil. This insect lays its eggs on the pod of the pea. The larva eats through the pod and enters the grain and destroys the germs. The weevil may be killed by placing carbon disulphide in the grain bins.

Hessian Fly. This insect attacks the stem of the wheat plant. It does not yield to direct treat-

ment. Late fall plowing helps to destroy late broods of the fly.

Helpful Insects. All insects are not injurious. Many are helpful or even necessary. Bees, both tame and wild, do the work of pollination for plants with pistil and stamens in different flowers. The dragon fly destroys large numbers of mosquitoes, both adult and as larvae. The ladybug devours great numbers of plant lice. Some insects are parasites in relation to other insects. Certain flies lay their eggs beneath the skin of plant lice. Ichneumon flies do similar injury to moths.

Birds and Insects. If it were not for the birds, crop-growing would be impossible. Insects make up part of the diet of nearly all birds, and almost the whole diet of some of them. The large number of insects they destroy leaves a big balance in their favor against the little they may use of our field and garden crops. Robins use a little fruit, but their chief diet is of grubs and worms. Crows take a little corn and other grain, but they also eat insects and destroy carrion. They are not numerous in Western Canada. Wild ducks, chickens, and geese sometimes make inroads in the grain fields, but, on the other hand, they furnish finely flavored meat. English sparrows eat some grain, but vary their diet with weed seeds and insects. Some of the hawks, such as the goshawks, steal an occasional chicken, but their steady diet is the

mice and other small rodents of the grain fields. The cowbird ousts many of the more useful birds from their homes, and prevents them from raising families, and so is not a helper.

Most of our birds, however, are wholly beneficial, and should be protected and encouraged. Their nests should not be disturbed. They can be encouraged to nest about the homes and gardens by setting up nesting places for them under the eaves, upon poles, or in trees. The variety of useful birds is very large, and includes the meadow-lark, robin, wren, woodpecker, cedar waxwing, snowbunting, kingbird, junco, vireo, nuthatch, warbler, thrush, butcherbird, and different varieties of swallows, hawks, and owls.

FIG. 76. THE KINGBIRD.

FUNGI

Fungi are a low type of plant organism or plants that reproduce by spores, and not by seeds as our crop plants do. They do not contain chlorophyll, which is the medium by which the higher plants manufacture food from the materials secured through the roots and leaves. One class of fungi

called **parasites** secure their food from the living tissues of plants and animals. Another class called **saprophytes** live on the decaying parts of plants or animals or really bring about the decay. The class which bring about decay are called bacteria, which are a simple class of fungi.

Parasitic Life. A **spore** is a single-celled body, so small that five thousand in a row would only extend one inch in distance. Spores are scattered by wind, or water, or insects. When a spore is in favorable conditions of moisture and heat, and has a suitable host, it starts to grow into a thread or series of cells. A host is a plant in which a particular kind of spore naturally lives and works. A series of cells is called a **hypha** (pl. hyphae). The hypha branches and grows into a bundle or mass of threads called a **mycelium** (pl. mycelia). It is the mycelium that absorbs nutrient material from the host and that produces new spores. Fungi, like all other plants, take their food by diffusion through their cell walls. Common examples of fungi that are of direct interest to the crop grower are the smuts and rusts of wheat, oats, and barley, the smut of the corn, the ergot of rye, and the scab and blight of the potato.

Smut. The smut fungus appears as a mass of black or brown powder in the heads of the grain. This dust consists of spores. When the grain is threshed this dust settles on the kernels. The

spores cling to the grain, and when it is sown they begin to grow up through the tissues of the plant and take possession of the head, and appropriate the food that would otherwise go to make the grain kernels. Wheat, barley, and oats have each two kinds of smut, closed and loose. The closed smut of the wheat and barley, and both kinds of oat smut, can be controlled by treating the seed grain. The closed smut of wheat is called stinking smut. The open smut of wheat and barley is early, and the spores are dispersed while the grain is just forming, and so it gets right into the kernels and cannot be reached by spraying the seed. Hot water dipping of the seed is sometimes employed, but this destroys some of the grain also. For the treatment of seed grain a forty per cent solution of formaldehyde is used. Corn smut is not subject to direct treatment. Smut masses should be burned.

Rust. Wheat, oats, and barley are subject to rust. The rust appears about the time grain is ready to head out. It consists of reddish brown, powdery streaks on the leaves and stem. The spores are blown about on the leaves and stems of other plants. Damp weather or dew induces multiplication where the spores fall. Finally the rust turns black, and persists on the straw over winter. Damp weather is thought to induce rust, but it only increases it.

Rust is not subject to direct control. Early crops are more likely to escape rust than late crops that run into cool, damp weather are. Rust is worse on low or undrained land than it is on windswept land, because of the deposit of moisture on the plants. Heat does not cause smut, though it may hasten the drying up of plants and the shrinking of grain where the tissues of plants are weakened and broken by the disease. Rotation of crops is unfavorable to rust. Some varieties of grain are less subject to rust than others, for example, durum wheat, or early varieties of oats, as compared with late oats.

Potato Scab is a fungus disease causing dry, scabby patches on the tuber of the potato. It gets worse every year if potatoes are planted a number of times in succession on the same land. The spores also persist on the potato itself. Rotation of crops, selection of seed, and formaldehyde treatment of seed are the remedies.

Potato Blight. The spores of blight persist in the potato and in the stalks. They work their way into the tissues of the leaves and destroy them. The disease gets to the surface by the leaf pores, the spores are distributed by the wind and developed by moisture. It is hard to control after it has got started. Frequent spraying with Bordeaux mixture is a preventive.

Ergot is a fungus that appears on rye, couch grass,

timothy, and other grasses. The spores are distributed by insects. It is worse on wet land than on well-drained land, but is not subject to direct treatment. It is injurious to live-stock.

EXERCISES

1. Explain how dry autumns may affect the purity of seed. 2. Why are certain weeds called noxious? Give examples. 3. Name three annuals, three biennials, and three perennials. 4. In how many ways do fanning mills improve seed? 5. Why are sheep considered the best class of stock to destroy weeds? 6. Explain carefully how the eating of the foliage of a plant affects the plant. 7. What insects are troublesome in your neighborhood and what plants do they attack? 8. Give other examples of fungi besides those mentioned above.

PART V—SUPPLEMENT

CHAPTER XXVII

TYPES OF FARM ENTERPRISE

Soil and Plant Interests are General Interests. The definition of agriculture given at the beginning of the book is, that it is the use of the soil for the production of plants and animals that are useful to man. We have learned a great many things about the properties of soils and about the behavior of plants, about the uses and methods of tillage, and about field crops, garden crops, and trees. These are things that boys and girls should know, whether the soil in which they are directly interested is the soil in the front and back of a city lot, or the soil in the fields. We have been able to study these things directly and practically because the soil is everywhere and it is used everywhere: in the gardens at home and at school, and in the nearby fields. Plants are found wherever soil is found. Many of the important things to be learned about soils and plants can be learned by bringing them into the school-room.

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Fig. 77*a*. The Beef Type.

Fig. 77*b*. The Dairy Type.

With farm animals it is different. Some boys and girls know a little about the art of caring for farm animals, but this can be properly learned only at home where the animals are kept. The science underlying the nourishment of farm animals is rather difficult, and besides it is interesting chiefly to the professional stock-raiser. We should all understand, however, the relation of stock-raising to tillage and crops, and we should know the special kinds of farm enterprises carried on in our country.

The Relation of Stock to Crops. It must be clear that animals depend upon crops just as crops depend upon soil. Both have to be fed. We know this from common observation, but we should know it better on account of our crop studies. Some of the crops we have studied are used directly and exclusively by man, such as the fruits and finer vegetables. Raspberries, tomatoes, and celery are good examples. Others, such as wheat, oats, barley, rye, and corn are useful, sometimes as to their different parts, for both man and animals. Still others, such as rape, hay, and other fodders, and coarse roots, are useful for stock only. But saying that some foods are used by man and some are used by stock, is just saying that man uses some foods directly and others indirectly. The ones that he uses indirectly are the ones that are changed by animals into such things as meat and dairy products. While people in the torrid zone live principally on

vegetable foods, and in the frigid zone on animal foods, in the temperate zone they live on a combination of these. It has been estimated that about forty-five per cent of the food used in the temperate zone is animal food, such as meat, milk, and eggs, and the rest fruit, vegetable, and cereal foods. Both by reason of the kinds of crops we grow and the way we live it would seem that the raising of animals is a most important side of agricultural production.

Stock-Farming and Agricultural Progress. So important is the raising of animals considered, that the perfection in which they are found, either generally or on individual farms, is the measure of progress in farming. The feeding of crops to stock is a method of concentrating rough feed and securing a good price for it. It not only saves or gives value to such feed, but the feeding of it to stock involves skilful management and labor for which the farmer gets paid. The value of the total output from land devoted to stock-raising is high. Stock-raising also conserves the fertility of the soil, because only a small per cent of the weight of the feed is actually assimilated and the rest is available in usable form to keep up the fertility of the soil. For these reasons stock-raising is commonly called the crown of agricultural production.

How Farm Enterprises Develop. The character of farm enterprises in a country like Western

Canada is a matter of general climatic and soil adaptations in the first place, and of the length of time land has been occupied in the second place. Prairie land has been used in the first place for two different purposes according to locality. The western prairie section was originally devoted to

FIG. 78. HACKNEY PONIES.

ranching and the middle and eastern sections to **grain-growing.** The mild winter climate and the short, but nutritious, sun-cured vegetation of the western section adapted it to pastoral use. The quality of grain grown on the other sections, due to rich soil, cold winters, moist growing season, and dry harvests, led to its use for the growing of

wheat. Both ranching and grain-growing are to some extent transitional, because they do not stand for the most profitable use of the land. Land that will grow good natural grass, will, generally speaking, grow tame grasses or grains profitably with the aid of cultivation, and stock may be raised in greater numbers than before. In the grain areas the natural increase of necessary stock and the need of keeping up the fertility of the land, soon result in turning grain-farming into general farming, though grain may be grown in as great quantity as before or in even greater quantity.

Mixed Farming. The first change then that occurs in new prairie countries is that simple enterprises change into complex ones. Most farmers after they have become established raise both crops and stock. Horses are necessary for the work of the farm; a few cows are necessary for the home supply of milk and butter; pork is the most easily kept meat for the farmer; sheep furnish wholesome fresh meat in conveniently small carcasses, and poultry supply both meat and eggs for the farm table.

All these likewise are, or may be made, revenue producers. Most farmers raise their own horses and a surplus besides. The sale for these is usually good where new country is being settled. Cattle are commonly the most important stock on the farm. They can make profitable use of large quantities of rough feed. The revenue from cattle

comes from milk and its products and from fat young stock and cows. A farmer seldom uses all the pork he produces or kills all his surplus sheep for himself. He also secures a revenue from wool. Every farm commonly produces a surplus of eggs and poultry. This is mixed farming, which is the growing of crops and feeding them to stock raised on the farm. In the best type of mixed farming all crops are fed, the stock or stock products being the ultimate products of the farm. This is what the farmer calls making his crops walk to market, which means that he is concentrating a lot of coarse, bulky feed into a highly finished and valuable product.

Live-Stock and Dairy Enterprises. While general or mixed farming enterprises are the most common, they usually turn into special enterprises to suit the tastes of the farmer, the proximity of markets, and the adaptations of particular farms. A farmer usually pays greater attention to the breeding and care of one kind of stock than to the others. It is usual to specialize in some of the larger classes of stock, such as horses or cattle, and to raise the smaller stock, such as sheep and swine, as side products.

Farms that will grow large quantities of coarse grains, forage, and roots are generally best suited to stock-raising. **Heavy horses** are generally better suited for breeding enterprises on the farm than

light horses are, because they are easily raised and because of the kind of work they can do. Besides this, light horses require more education and care than the general farmer has time for. **Beef cattle** are more commonly bred by farmers than dairy cattle are in sparsely settled countries. Certain breeds of cattle, notably the Shorthorn, will

FIG. 79. A DUAL PURPOSE SHORTHORN.

yield a good deal of milk, will breed good beef cattle, and will make good beef themselves besides. The special dairy breeds on the other hand do not fatten well, when they are no longer profitable for milk, nor will their stock fatten well. A cow that is good for both purposes is called **a dual purpose cow.** It is plain that such a cow is a good one for the general farmer. This quality in the Shorthorn is

not general, but belongs to certain strains or families. In Canada the Shorthorn has been bred principally for beef in the past, but the dual purpose type is receiving a great deal of attention and herds will increase rapidly. In the old country it is commonly estimated that the Shorthorn and the grades

FIG. 80. A PAIR OF TWIN DORSET EWES.

of Shorthorn furnish both more milk and more beef than all the other breeds of cattle together. Special **dairy enterprises** are suited to farms that are close to cities, or generally to places well settled and with good transportation services. Dairying furnishes steady revenue throughout the year, and enables the farmer to pay as he goes.

Sheep. Sheep are not commonly the leading class

of stock on western farms. Special sheep enterprises are limited to ranching, or to the fattening of sheep on the screenings of the elevators. Small flocks of either grade or pure-bred sheep can be satisfactorily kept along with other kinds of stock, except dairy cows. They consume rough feed, such as weed seeds, small grain, and rough fodders, destroy weeds on the summer-fallows and other parts of the farm, and furnish a wholesome kind of fresh meat in summer time. They require close fencing to hold them, and also to keep out predatory animals.

Angora Goats are raised to a slight extent in the brushy parts of the West.

Swine require careful and regular attention and considerable concentrated food, and, except under careful management, are better as a side line in live stock than as a specially large enterprise. The hog business can be successfully carried on along with dairying, where only the cream or butter is disposed of. As with other classes of meat stock, there is a tendency to change the method of raising hogs on concentrated feed, to a system of grazing in summer and feeding more on nitrogenous foods and roots, rather than on fat-producing foods, in winter, in order to meet the demand for lean or mixed meat. This change also illustrates an advance in economy in feeding by the use to the fullest extent of cheaply produced foods.

FIG. 81. THE SHIRE.

FIG. 82. THE BELGIAN.

Horses for Power. Horses are in a different class from cattle, sheep, swine, and poultry, as to use or purpose on the farm. They are sometimes called the power stock of the farm. All of the work connected with the use of implements and machinery, the hauling of loads, and the transportation of people, was formerly done by horses. In the Southern States mules are extensively used instead of horses, and oxen are common in our own country in newly opened districts. In certain large farm enterprises steam and gasoline engines are used for breaking, and for the driving of machinery, both heavy and light. Motor rigs are doing a good deal of both the freight and passenger transportation in cities, but in the country their use so far is limited to light driving. It is not likely that the horse will be superseded for the furnishing of power on the ordinary farm, except for stationary work, such as the driving of pumps, choppers, separators, and threshing machines. In some of the countries of Europe, notably France and Germany, the flesh of the horse is used for food.

CHAPTER XXVIII

TYPES AND BREEDS OF FARM ANIMALS

The Improvement of Live Stock. Though the greater part of the common stock of the farm is not pure-bred, we have in all classes of stock a great many different well-established breeds. There are enough of different breeds in all classes of stock to make it possible for anyone to find a breed suited to his taste. It is by keeping to the same breed of animals steadily and keeping the best of them, that good animals have been produced and that all animals have been improved. The keeping of the best stock is called **selection.** When a breed becomes well established, the fanciers of the breed get together and fix a standard of excellence for it, which takes account of certain points, such as weight, height, color, conformation, and other features. Animals that come up to the standard are recorded in a register kept for the purpose, and the owners are given a certificate which is evidence of pure breeding. The recording of pure-bred animals in Canada is under the direction of the various breed societies, subject to inspection by the Dominion Department of Agri-

culture. The word **thoroughbred** is sometimes used in the sense of **pure-bred,** but this is incorrect. It is not correct to speak of thoroughbred pigs or cattle. The word thoroughbred applies only to the English race-horse. An animal that is not pure-bred may be either a **cross** or a **grade.**

Care has as much to do with producing good animals as selection has. The influences outside of good breeding that altogether affect the growth of an animal are called the **environment.** This is made up of care, shelter, feeding, and also climate and soil, though sometimes environment is used to stand for natural influences only. Good examples of the effect of environment appear in the difference between the Clydesdale and the Shetland, one of which may weigh a ton and the other stop at three hundred pounds, or in the Welsh pony and the Shire, or the Welsh Mountain sheep and the Lincoln. Two Hereford cattle of equal breeding, size, and quality may be placed on adjacent farms. One may improve and the other deteriorate on account of the difference in care. The chief thing to be learned from this is that good breeding is of no use without good care. Pure-bred animals will repay good care better than others, but will not stand hard conditions any better.

Where herds or flocks of good stock are owned near the school, the teacher and pupils should visit the farm by arrangement with the owner, to learn

something about types of animals, and also about the care of animals.

Horses. According to use horses are commonly described as heavy, general purpose, and light. The pure-bred horses that are raised in Western Canada may be conveniently grouped into two classes called draft horses and light horses. The breeds included are as follows:

Draft Horses:

Clydesdale.
Percheron.
Shire.
Suffolk Punch.
Belgian.

Light Horses:

Hackney.
Thoroughbred.
Standard-Bred.

The draft horse is used for moving heavy loads. He is low set and blocky in type, with heavy limbs and large feet, and generally moves slowly. Light horses have smaller bodies, longer and lighter limbs and smaller feet than draft horses have. Horses of similar type to the Hackney are the French and German coach. These are all carriage horses of good size, the Thoroughbred and Standard-Bred being relatively small. Along with the Thoroughbred we may class the Irish Hunter. These are both strictly saddle horses. The Standard-Bred is used in harness only. Horses of the

Standard-Bred and Thoroughbred classes are bred wholly for speed, the gait of the latter being a gallop and of the former the trot or pace.

In addition to these groups we have a class of ponies including the following kinds:

Ponies:

Shetland. Hackney. Welsh.

The first two are used by children for riding and driving, and the last by ladies for park driving.

The **bronco** is a half-wild pony of Western Canada and United States. It is known as the **mustang** in Mexico and as the Indian pony or **cayuse** in Canada. The bronco is not established or held as a breed, but is being rapidly transformed by mixing with the improved breeds.

FIG. 83. SHETLAND PONY.

The meaning of the name itself has been changed, so that it now stands for any wild or unbroken prairie horse independent of breeding. The bronco is distinguished for good wind, sound digestion, and general hardiness, and no doubt contributes

some of these qualities to the stock with which it is interbred.

Cattle. The chief breeds of cattle raised in Western Canada are:

Beef Breeds:

Shorthorn.	Aberdeen-Angus.
Hereford.	Galloway.

Dual Purpose:

Shorthorns (certain strains).	Red Polled.

Dairy Breeds:

Holstein-Friesian.	Jersey.
Ayrshire.	Guernsey.

The Shorthorns and Herefords are the heaviest of the beef breeds. They are big, growthy, square-built cattle. The Aberdeen-Angus is round in conformation rather than square. The Galloway is a heavy-coated, hardy animal. Both the Galloway and the Aberdeen-Angus are black, while the Shorthorns are red, roan, or white, and the Herefords are red and white. The

FIG. 84. THE SHORTHORNS ARE RED, ROAN, AND WHITE.

Red Polled cattle are medium sized, general purpose cattle, but are not very numerous. Holsteins are the largest and give the most milk of any of the dairy breeds. Jerseys and Guernseys give the richest milk, while the Ayrshires are of intermediate type. The Holsteins are used for milk production. The Jerseys and Guernseys are not large and make good family cows, as well as general dairy cows, where butter-making is the leading interest.

Beef and Dairy Form. There is a strong contrast between typical beef and dairy cattle in appearance and in actual conformation. The cattle that are best for beef are blocky, solid cattle, approximating generally to a rectangular solid in shape. They are both wide and deep, and have short legs and necks, and are well covered with flesh. Their ribs spring widely from the back, so as to give width to the body throughout. The good dairy cow, on the other hand, is rather thin in appearance. She is poorly covered with flesh and shows a wedge shape in three directions. She is deeper behind than in front when viewed from the side, thicker behind than in front when viewed from the front, and thicker below than above when viewed from the top. She has light hams, rather flat ribs, and a rather long, thin neck. The barrel is rather large, which indicates a good capacity to make use of food. Both beef and dairy cattle should have good heart girth suited to their general conformation.

Sheep. There are two main purposes for which sheep are kept and two general groups into which they fall. All sheep produce both wool and mutton. The English breeds are the better ones for mutton and are more profitable farm sheep than the Merinos are, but do not produce such fine wool. The Merinos are well adapted to being kept in large bands, and most of the range sheep are Merinos, or are partly of Merino blood. Special mutton sheep and special wool sheep differ in form and appearance somewhat as the beef and dairy types of cattle differ. Mutton sheep are large, square-bodied sheep with well sprung ribs and good fleshing qualities. The special wool sheep are rather small and thin looking. They have sloping or flat ribs and are not well fleshed any place. Those producing the finest wool are quite wrinkly in the skin. Of the English breeds, the Middle-wooled, dark-faced sheep are preferred in the Prairie Provinces. Dense-fleeced sheep do not lose their animal warmth readily, nor does the snow penetrate easily to the skin. They are generally hardy. The classes and breeds are commonly grouped according to the kind of wool they have and are as follows:

Long-wooled Breeds:

Leicester.	Cotswold.
Lincoln.	Romney Marsh.

Fig. 85*a*. Special Wool Type.

Fig. 85*b*. Special Mutton Type.

Middle-wooled Breeds:

Southdown.	Hampshire.
Shropshire.	Suffolk.
Oxford.	Dorset.

Fine-wooled Breeds:

American Merino.	Rambouillet.
Delaine Merino.	

Swine. The demand for bacon has had an important influence on the character and conformation

FIG. 86. GOOD THRIVERS.

of the breeds of hogs. Hogs are generally classified as lard hogs and bacon hogs, but in Canada most of the breeds are being assimilated to the bacon type. The bacon type is a long, comparatively thin hog, with deep sides, smooth shoulders, and trim hams. The lard hog is a shorter hog, with

thick back, shoulders, and hams. The two classes are represented chiefly by the following breeds:

Bacon Hogs:

Yorkshire. Tamworth.
Berkshire.

Lard Hogs:

Duroc-Jersey. Poland China.

Other breeds represented are the Hampshire, an intermediate type, and the Chester White, which is a large, lard hog.

Poultry. The keeping of poultry is common to the country and town or city lot. In the towns and cities the interest is largely limited to chickens; in the country, ducks, geese, and turkeys are also raised. In addition to their value for their eggs, flesh, and feathers, the different kinds of poultry help to destroy insects. Chickens are of great variety, but fall into three general types, which may be called egg breeds, general purpose breeds, and meat breeds, of which a few representatives are given:

Egg Breeds:

Leghorn. Minorca. Spanish.

General Purpose Breeds:

Plymouth Rocks. Orpingtons.
Rhode Island Reds. Dorkings.
Wyandottes.

Meat Breeds:

Brahma. Cochin. Langshan.

Besides these we have fancy breeds represented in the games and bantams. Varieties of the general purpose type are commonly preferred in the country, and egg breeds and general purpose breeds in the towns. Poultry interests are connected more with the interests of the house than with those of the farm, and are commonly taken account of by the boys and girls, who make profit from keeping and caring for their birds.

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